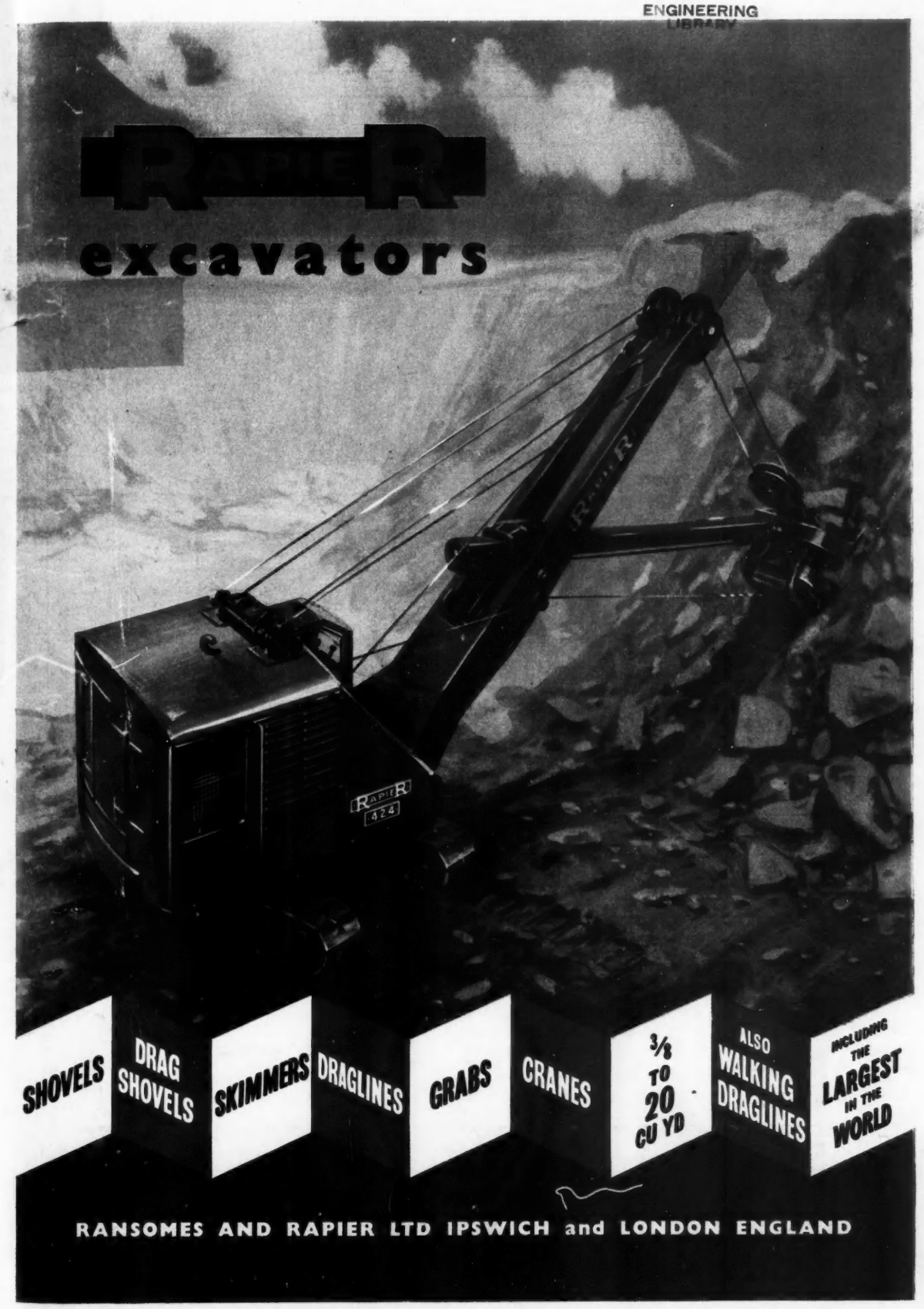
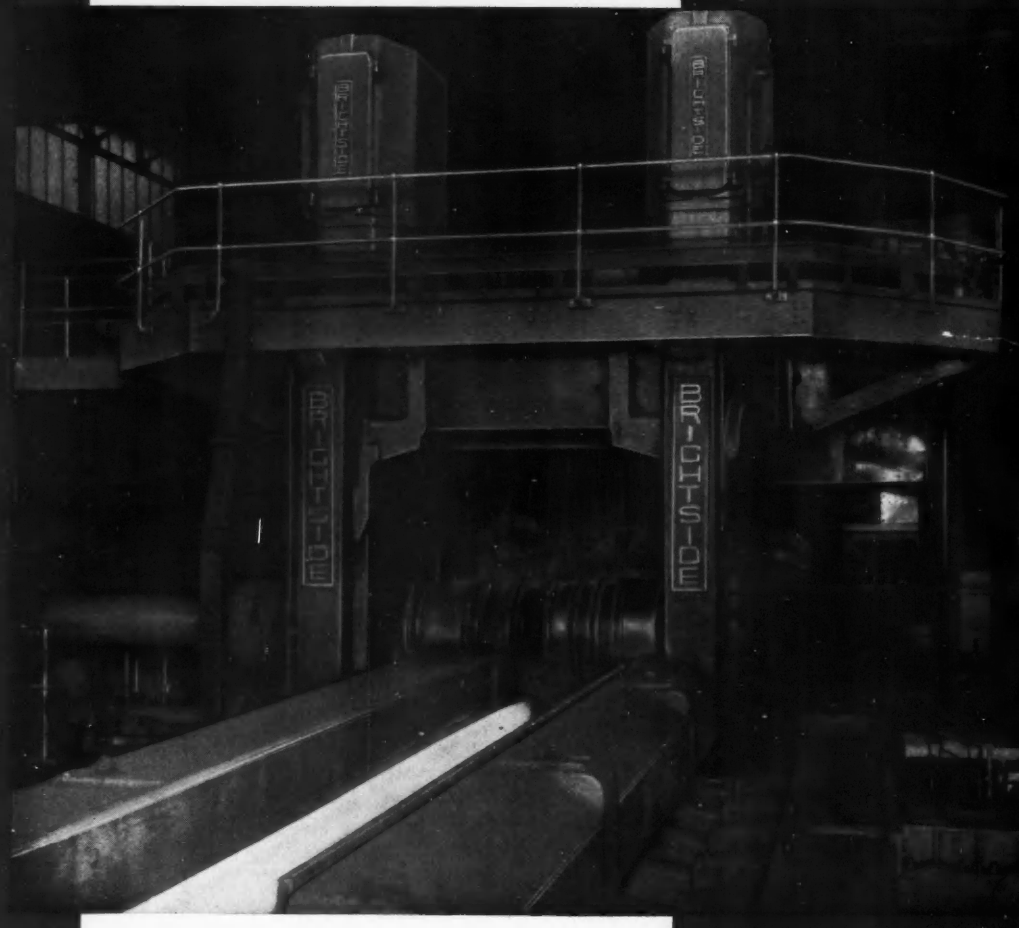
The Engineer

NOVEMBER 1, 1957 28 ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS

ENGINEERING LIBRARY



BRIGHTSIDE



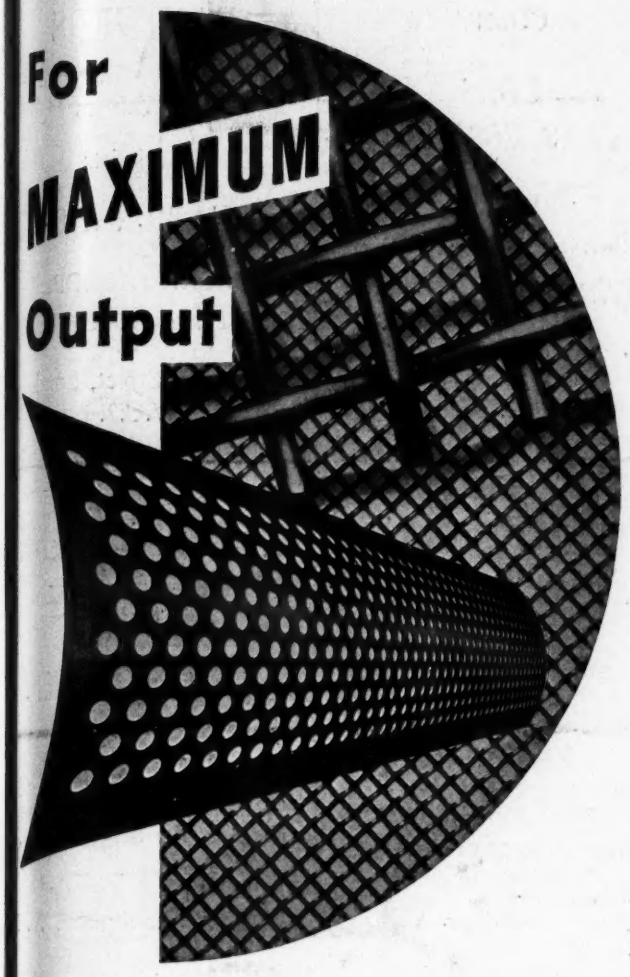
HOT & COLD ROLLING MILLS
ROLLS FOR HOT & COLD ROLLING
ROLL LATHES
HOT & COLD SHEARS
HOT SAWS & REELERS
STEELWORKS PLANT & AUXILIARIES

The 34" Blooming Mill

Photograph by courtesy of Llanelly Steel Co. (1907) Ltd.

THE BRIGHTSIDE FOUNDRY & ENGINEERING CO. LTD.

G.P.O BOX 118, SHEFFIELD 1.



Maximum output calls for screens that are tough enough to withstand long periods of gruelling service, and so reduce to a minimum delays for repair or replacement. In fact, maximum output calls for

'HARCO'
PERFORATED METAL AND WIREWORK
SCREENS

Supplied as flat or curved plates, or as complete screens to specification, in a wide range of gauge, mesh and pattern for every screening, sorting or sizing requirement.

Please send for Catalogues Nos. E858 and E926.

Harvey

G. A. HARVEY & CO. (LONDON) LTD.,
Woolwich Road, London, S.E.7. Telephone: GREenwich 3232 (22 lines).

THE ENGINEER

ESTABLISHED 1856

28 ESSEX STREET, STRAND, LONDON, W.C.2.

Telephone: CENtral 6565

Vol. 204 No. 5310

NOVEMBER 1, 1957

Published every Friday Registered as a Newspaper

PRINCIPAL CONTENTS

(Complete contents on page 621)

The Excitement of the Future 621

Britain's Naval Choice 622

Theory of Shaft Whirling—No. IV.....624

Developments in Underground Gasification.....633

International Motor Show—No. III.....628

Some Current Practice with Computers. 638

International Astronautical Conference.....640

Richmond–San Rafael Bridge—No. I.....651

Reconstruction of August Thyssen-Hütte—No. I 649

NOTICE TO READERS

All letters intended for insertion in "The Engineer" or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

SUBSCRIPTIONS

U.K. and ABROAD £5 10. 0. per annum, including postage (CANADA £5 5. 0.) Single copies 2s. each, plus 9d. postage. Also on sale at newsagents.

'THE ENGINEER' BUYERS GUIDE

Published annually. One FREE copy is sent to all direct postal subscribers on publication and delivered by newsagents to all regular readers. Additional copies are obtainable at 7s. 6d. each. Postage 1s. 9d. extra.

CLASSIFIED ADVERTISEMENT RATES—see page 2.

DISPLAY ADVERTISEMENT RATES—on request from The Manager.

Published by
MORGAN BROTHERS (PUBLISHERS) LTD.,
at 28 Essex Street, Strand, London, W.C.2.

INDEX TO ADVERTISERS.....PAGE 139

AUCTIONEERS & VALUERS

ESTABLISHED 1877

LEOPOLD FARMER & SONS

conduct

AUCTION SALES OF PLANT, MACHINERY AND INDUSTRIAL PROPERTIES

and

VALUATIONS

for Public Issue, Stock Exchange Quotation, Balance Sheet, Probate Insurance and other purposes.

FACTORY INVESTMENTS AND MORTGAGES ARRANGED

46, GRESHAM STREET, LONDON, E.C.2.

Telephone: Monarch 3422 (8 lines) Telegrams: Sites, London

FULLER, HORSEY

SONS AND CASSELL

Specialists

IN THE

SALE & VALUATION

OF

WORKS and MANUFACTORIES

ENGINEERING PLANT

and MACHINERY

10, LLOYD'S AVENUE, LONDON E.C.3.

Telephone: ROYAL 4861

AUCTIONEERS & VALUERS

Established 1850

WHEATLEY KIRK PRICE & CO.

E. L. JUDSON, F.R.I.C.S., F.A.I.
E. BEDDARD, A.I.MECH.E., F.A.L.P.A.
M. E. CHEAVIN, F.A.I.
G. E. GIBBS, F.A.L.P.A.

SURVEYORS, VALUERS and AUCTIONEERS of FACTORIES, PLANT and MACHINERY

FIRE LOSS ASSESSORS

9, REX PLACE, LONDON, W.1.

Telephone: HYDE PARK 8844/5/6 (3 lines)

HENRY BUTCHER AND CO.

Auctioneers, Valuers and Surveyors

Specialising in the

SALE & VALUATION of ENGINEERING & ALLIED WORKS PLANT & MACHINERY

73, Chancery Lane, London, W.C.2.

HOLBORN 8411 (8 lines)

AUCTIONEERS & VALUERS

JOHN FOORD & COMPANY

VALUERS AND ASSESSORS

OF WORKS, FACTORIES ENGINEERING PLANT AND MACHINERY

56, VICTORIA STREET LONDON, S.W.1.

VICTORIA 2002/3/4

Established 1807

EDWARD RUSHTON, SON AND KENYON

EST. ERS&K 1885

SALES BY AUCTION

Sales by Auction or Private Treaty of factories, plant and machinery.

VALUATIONS

Valuations for Going Concern, Fire Insurance and Rating Purposes.

FIRE LOSS SETTLEMENTS

Detailed Claims prepared and settlements negotiated on behalf of the insured only.

YORK HOUSE, 12 YORK STREET MANCHESTER, 2

Telephone: CENtral 1937
Telegrams: "Russonken, Manchester"

AUCTIONEERS & VALUERS

RICHARDS AND PARTNERS

Auctioneers, Surveyors and Valuers

Specialists in the

VALUATION & SALE of INDUSTRIAL PROPERTY PLANT and MACHINERY

3, Arundel Street, London, W.C.2.

TEMple Bar 7471

KNIGHT, FRANK & RUTLEY

SALE & VALUATION OF FACTORIES PLANT AND MACHINERY

20, Hanover Square, W.1.

Telephone: MAYfair 3771

(Factory Department: Ext. 17)

CLASSIFIED ADVERTISEMENTS

AGENCIES • DIRECTORS • PARTNERSHIPS
BUSINESS OPPORTUNITIES • EDUCATIONAL • PATENTS
BUSINESSES and PREMISES • MISCELLANEOUS • PUBLIC APPOINTMENTS
SITUATIONS VACANT • TENDERS

Lineage Rate. 3/6 per line. Minimum 4 lines. The line averages 6 words.
Inch Rate. 42/- per single column inch and pro rata. Minimum 1 inch.
Series Rates—per inch and pro rata, per insertion.
6 insertions 40/-. 13 insertions 38/-. 26 insertions 35/-.

AUCTIONS • FOR HIRE • MACHINERY etc. WANTED
DRAWING AND DESIGN SERVICES • FOR SALE • SITUATIONS WANTED
SUB-CONTRACTING

Lineage Rate. 3/- per line. Minimum 4 lines. The line averages 6 words.
Inch Rate. 36/- per single column inch and pro rata. Minimum 1 inch.
Series Rates—per inch and pro rata, per insertion.
6 insertions 34/6. 13 insertions 32/6. 26 insertions 30/-.

Box Numbers. 2/- extra, except in Situations Wanted, where they are free. Replies are re-addressed immediately without further charge.

Copy Date. "Run-on" and "Semi-Displayed"—by noon on Tuesday for publication on Friday of the same week.
"Displayed" and "Illustrated"—by noon on Friday for publication on the following Friday.

For styles and sizes of "Run-on", "Semi-Displayed", "Displayed" and "Illustrated" Classified Advertisements please send for Circular.

Advertisements for publication should be addressed to:—
Classified Advertisement Dept.,
"The Engineer", 28 Essex Street, Strand, London, W.C.2.
Urgent advertisements may be telephoned to CENtral 6565.

E. R.

By Order of the Minister of Supply

GOVERNMENT SURPLUS STORES

AUCTION PROGRAMME

		Main Location	*Auctioneers*
November 6	Miscellaneous stores	Northern Command Ordnance Sub-Depot, Barlow, Nr. Selby, Yorkshire	BARTLE & SON (Dept. L), 50–52, Merrion St., Leeds, 2. (Tel.: 2-0898.)
November 11–15	Vehicles, lifting and earth moving equipment	M.O.S. Storage Depot, Ruddington, Notts	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham (Tel.: 47271.)
November 14	Miscellaneous stores, including :—	Returned Stores Depot, British Railway Sidings, Colley Lane, Bridgwater. (Sale at Royal Clarence Hotel.)	J. H. PALMER & SONS (Dept. L), Bank Chambers, Burnham on Sea, Somerset. (Tel.: 2326.)

Camp and tent equipment, blankets, groundsheets, portable and insulated containers, large quantity of hand tools and bench vices, large quantity of fire-fighting equipment, 75,000 entrenching heads and helves, 4000 portable cookers, flarelights, office safes, furniture, including wardrobe, dining tables, filing cabinets, chairs, etc., water fittings, etc.

November 21	Miscellaneous stores, including :—	M.O.S. Storage Depot, Rotherwas, Hereford	RUSSELL, BALDWIN & BRIGHT, LTD. (Dept. L), 20, King Street, Hereford. (Tel.: 4366.)

Tyres, inner tubes, marine engines and gears, Albion, Humber, Hillman, Morris, Wolseley, Standard, Thornycroft, Ford, etc., engines, front and rear axles, gearboxes, transfer units and other M.T. spares, Barber Green paver finisher, radio and electrical equipment, cable, telegraph poles, signal satchels, Singer sewing machines, generating and lighting sets, switchgear, scrap batteries, oil units, clothing, etc.

November 25–29	Miscellaneous stores, including motor vehicles, motor cycles and trailers	M.O.S. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18	FULLER, HORSEY, SONS & CASSELL (Dept. L), 10, Lloyds Avenue, London, E.C.3. (Tel.: Royal 4861.)

CATALOGUES (6d. each—P.O.s) available *only from the auctioneers* shown above.

SALE BY TENDER

MACHINE TOOLS :—Universal, surface, internal and cylindrical grinders, centre lathes, 16ft.–30ft. between centres, boring machines, 11ft.–28ft. stroke, honing, reaming, rifling and deep hole drilling machines, lapping, shaping and centring machines, are offered for sale by tender. Application for Tender Forms should be made to Ministry of Supply Disposals 2(b), (Dept. L), First Avenue House, High Holborn, London, W.C.1. Tenders must be submitted by November 18th. E975 1

THE ENGINEER

VOL. 204 No. 2310 NOVEMBER 1, 1957

CONTENTS

LEADING ARTICLES—
Excitement of the Future 621
Britain's Naval Choice 622

ARTICLES—
B.B.C. Ultra-High-Frequency Transmissions 645
Brewers' Machinery. (Illus.) 641
Composite Steel and Concrete Construction. (Illus.) 646
Crankshaft Grinding Machines. (Illus.) 647
Developments in Ultrasonic Machining 635
Developments in Underground Gasification. (Illus.) 632
Diesel-Electric Shunting Locomotive. (Illus.) 645
Endless Chain Tub Creeper System ... 642
Experimental Battery Railcar 623
Hydraulic Gear Motors... 642
International Astronautical Congress... 640
International Motor Show. No. III. (Illus.) 628
Light Commercial Vehicles 647
Marine Propulsion Research. (Illus.)... 644
Precision Engineering Research 623
Regrading a Trunk Road. (Illus.) ... 646
Sir Harry Railing 623
Some Current Practice with Computers. (Illus.) 638
South Wales Institute of Engineers ... 646
Technical Services Laboratory for Oil Fuels and Lubricants. (Illus.) ... 643
Theory of Shaft Whirling. No. IV. (Illus.) 624
Unusual Corrosion Problem... 635
Utilising Natural Gas in Scotland ... 623
Withdrawal of Offer to Build Nuclear Reactor 623
100 Years Ago... 622

CONTINENTAL SECTION—
Reconstruction of August Thyssen Hütte. No. I. (Illus.) 649
E.C.E. Committee on Electric Power... 650
Ball Thrust Bearing for High Speeds ... 650
International Federation for Automatic Control 650

AMERICAN SECTION—
Richmond–San Rafael Bridge. No. I. (Illus.) 651
Aeronautical Research Meetings in the U.S.A. 653

LETTERS AND LITERATURE 636

LETTERS TO THE EDITOR—
Technology and Wisdom 636
Purifying Brackish Water by Electro-Dialysis 636

BOOK REVIEWS 637

NEWS AND NOTES—
Advanced Engineering Courses 656
British Patent Specifications. (Illus.)... 655
Forthcoming Engagements 656
Industrial and Labour Notes... 648
Launches and Trial Trips 656
Personal and Business 654
Technical Reports 637

THE EXCITEMENT OF THE FUTURE

The really remarkable thing about the presidential address that Sir George Nelson presented on Friday of last week to the Institution of Mechanical Engineers and which we printed almost in full in our last issue was that for the most part it dealt with a threadbare subject; yet it proved absorbingly interesting! Within the last twelve months and more the need for this country to train more technologists has been preached *ad nauseam*. We ourselves have contributed to the chorus and Sir George Nelson, in covering that subject, provided no new statistics or figures to illustrate his points. What he did instead was to look at the problem in an unfamiliar and attractive way. His way was particularly attractive to us because it emphasised that unity within engineering which we believe persists despite the growth of specialisation. Sir George, with experience of mechanical, electrical, electronic, aeronautical and nuclear engineering behind him, stressed the need for an engineer to possess sound fundamental knowledge. For, in solving an engineering problem to-day, no one man can fully weigh all the technological factors involved. Specialists must be consulted. But only if engineering fundamentals have been absorbed will a man readily consult other experts without shame of his ignorance, or appreciate to the full the implications of what they tell him for the problem in hand. Part of the reason why Sir George was so successful in presenting his address was that he drew into a single theme the need to educate more technologists, the need to educate the whole population in the elements of science, and the need to ensure that people in high positions have sufficient scientific and technological knowledge to appreciate and assess what experts tell them. Another reason for his success in presenting his subject lay in his approach to it. Significantly, towards the end of his address, he remarked that he found the future more interesting and more exciting than the past. It was this sense of the urgency, because of the exciting powers coming within man's grasp in the future, of reaching wise decisions about the education of engineers and about their effective use in industry, which, we believe, made the address so attractive. And how much we agree with him! For we doubt whether in the last 1500 years and more there has been an age more potent with astonishing possibilities than ours; and those possibilities have been created almost wholly by scientists and technologists. Certainly in that long period there has never been a time when the future seemed so relatively much more exciting than the past. For, from the time of the decline and fall of Rome almost until the opening of the present century, men looked back in awe to the achievements of that ancient civilisation rather than in excitement towards any future possibility of surpassing them. With the coming of the Renaissance, other wonders, lost in mediæval times, were rediscovered. The richness of Greek thought and the magnificence of Roman living influenced all European thought thereafter. Throughout the seventeenth and eighteenth centuries and well into the nineteenth, educated men nostalgically looked back to Rome, as Trevelyan has pointed out, as a civilisation comparable in many respects to their own and still in many ways superior to it. Excitement thus lay rather in a study of the past than in thoughts about the future. But to-day, primarily as a result of scientific discoveries made only within the present century and quite recently applied by engineers, the technical achievements of Rome have shrunk in significance. They are no longer "absolutely" remarkable wonders never to be surpassed; but remarkable only relatively to the early period in which they were achieved. Our own technological achievements now surpass them and our administrative problems, in consequence, have become far more complex than those of Rome.

It is, of course, because for so many centuries men looked back to Greece and Rome as a source of knowledge surpassing anything contemporary, that Greek and Latin achieved pre-eminence as subjects which no man claiming to be educated dared neglect. There is still to this day something to be learned from Greek and Roman history and literature. But as we move into a future which leads Heaven knows where, problems crowd about us, for the solution of which Greek or Roman experience provides uncertain guidance. For to-day decisions cannot be taken solely on ancient administrative precedents. Technological questions intrude. They intrude so much that jealous national sovereignties fall down before them as, for example, in the coming of the Euro-

pean Economic Union, Euratom and many other international technical bodies. In the last sixty years technological advances have utterly changed the circumstances in which people live and in which nations associate. Within two days any point on the earth can now be reached from any other point. Men, however widely separated in distance, can talk with one another. Civil engineering mastery over nature has proceeded so far that in carrying out great engineering schemes for irrigation, flood control, power supply and the like, the mere existence of national boundaries cannot be permitted to interfere unduly with the attainment of the most economic technological solution. Nor, as man draws ever more heavily on the mineral resources of the earth, can parochial national jealousies be allowed to stand in the way of their development. Technological questions, because they influence the lives of everyone, and because they are intimately related to standards of living, enter explicitly or implicitly into every international discussion. Nothing of importance to-day can be wisely decided without reference to some technological question. The presence of the " Sputnik " circling the earth every ninety-five minutes is a portent, promising an exciting adventure of the future yet to come—the exploitation of the solar system. But if it is to be exploited in peace and not in war, then in our view the attitude of mind of the technologist, seeking to gain the highest attainable economic advantage by using available technological knowledge to the full, rather than that of the national statesmen seeking a limited advantage for his nation alone, is the one that will need to be adopted. We need therefore to look forward to a day when men will be as ashamed to confess to lack of any knowledge of science as they are to-day to confess to ignorance of the arts and humanities.

BRITAIN'S NAVAL CHOICE

The British officials who were privileged to go to sea in the U.S. submarine " Nautilus " during her recent visit to this country are no doubt wondering how Britain can afford to install so revolutionary a power plant in ships of the Royal Navy while continuing to build up Allied retaliatory power. To guard the sea communications, Britain requires surface warships more urgently than submarines. But the " Nautilus " has conclusively proved the great advantage of nuclear propulsion for surface ships. Between January, 1955, when she commissioned for service, and April, 1957, when she " refuelled " for the first time, she travelled well over 60,000 miles. Most of this distance was covered at speeds of over 15 knots and it could equally well have been done, with little or no more consumption of nuclear fuel, at speeds of between 20 and 25 knots, which this vessel is capable of maintaining for prolonged periods. Her success has convinced the U.S. naval authorities that nuclear power plants must be the conventional power plant for all future fighting ships of destroyer size and above. At the present time, the United States Navy has—built, building or authorised—thirteen general purpose submarines (including the " Nautilus " and " Sea Wolf," already in commission) ; a larger submarine with a two-reactor power plant ; and a still larger rocket-firing submarine—all with nuclear propulsion. The United States is also building an atomic-powered cruiser and a power plant consisting of eight reactors for an 85,000-ton, 33-knot aircraft carrier, on which construction is about to commence. According to Admiral Rickover—who was mainly responsible for the design of the " Nautilus " and is now chief of the Naval Reactor Branch of the Atomic Energy Commission—the U.S. Navy will have a nuclear task force, complete from submarines to aircraft carriers, by 1965.

Until recently, Britain required her stocks of uranium 235 and plutonium for the production of missiles and it was only about two years ago that, in the absence of information from the United States, we were able to do our own pioneering work by designing the " Dreadnought." We may hope to see this vessel in service in four or five years' time—a nuclear-powered submarine with a pressurised boiling water reactor similar to the type to be fitted in fourteen of the United States' fifteen submarines (the " Sea Wolf " has an experimental reactor). The " Dreadnought " will be an expensive ship, for the " Nautilus " cost £7,000,000 to build, excluding the cost of the development work. But she will no doubt be followed by more vessels of this kind. There are obvious advantages in having submarines which can steam off in any direction for any length of time required at 25 knots and at a depth of 600ft and more. Before, however, we can think of the large-scale building of surface ships with nuclear power plants, it must first be decided what part the Royal Navy is to play in the event of war. Is the Navy intended only " to provide means of bringing power rapidly to bear in peace-time emergencies or limited hostilities " ? If so—and this is clearly the view of the Government—then perhaps we can make do for several years with our existing carriers and cruisers and with the kind of building programme now in hand—the construction of four fleet escort vessels equipped with anti-aircraft guided missiles. So long as our existing ships are fit to steam and provided our carriers are brought up to date to operate modern swept-wing aircraft, the Royal Navy could no doubt give the necessary aircraft and gun support to our troops ashore in a localised war, when our opponent was not a major power.

But if we accept, instead, the First Lord's view that the Royal Navy must be ready for any kind of war, we cannot long delay a rebuilding of our Navy with nuclear-powered ships. Despite the special responsibility of the Royal Navy and the R.A.F. coastal command for the defence of the Eastern Atlantic, the British Naval Commander-in-Chief, Eastern Atlantic Area—fully supported by his R.A.F. colleague—has recently told us that he cannot carry out the task given to him with the maritime forces placed at his disposal. What, then, could he hope to do against large numbers of nuclear-powered submarines and supersonic aircraft ? We may be quite sure that among the 100 submarines Russia is now building—she will have 700 by 1960—many will be equipped with nuclear power plants. Fleet trains are not the answer. Warships will require to proceed for prolonged periods at high speeds and must not be hampered by fuel requirements. They must be nuclear powered. We are in fact soon to be faced with the alternative of building ships costing at least twice as much as they do now or continuing to add expensive weapons to an already adequate deterrent. We cannot afford to do both.

The Engineer
100 Years Ago
(OCTOBER 30, 1857)

" L'ANGLETERRE CONTINENTALE "

" Under this alarming title the *Siècle* gives us some information with respect to a project for connecting England and France by a submarine tunnel. The following is abridged from the article.

" We assure our readers that we are not speaking now of any wild project which it is always easy to conceive when once in the domain of social or political fantasy. The possibility of uniting England and France by means of a submarine tunnel has been practically and scientifically considered by a skilful engineer, M. A. Thomé de Gamond. This gentleman has submitted his project in the first place to the Emperor, who was greatly struck with it. Afterwards the Minister of Public Works, in accord with the Minister of Marine, named a special commission, composed of the most eminent scientific notabilities. This commission has decided that M. Thomé de Gamond was no mere dreamer. The English Government have also named on their side a commission, and it is probable that in the coming spring French and English engineers will apply themselves to the work of vigorously examining the practicability of the project.

" In the actual state of his researches the following is a sketch of the project of M. Thomé de Gamond :—The tunnel will commence on the French coast at Marquise, a small town of the Pas-de-Calais, from which it will branch on one side to the Boulogne Railway, and on the other to the Calais line. The first of these branches will be 13,700 metres in length, and the second about twenty kilometres. The tunnel will extend from Marquise 8,800 metres towards Cap Grinez, at which point it will enter the Straits and strike the English coast at Eastware, between Dover and Folkestone. A branch of 5,500 metres will connect the tunnel with Dover and all the net-work of the English railways."

A Seven Day Journal

Precision Engineering Research

On Wednesday of last week, the Minister of Supply opened the new building at the Castlereagh factory of the Precision Engineering Division of Short Brothers and Harland, Ltd., which is to house the research department of the parent firm. The entrance was closed with a tape of aluminium foil reinforced with nylon ribbon and rendered combustible with waxed paper ; it was ignited by the Minister with a " pistol " delivering a high-frequency, low-energy voltage to a pointed probe producing intense local heating of the aluminium.

Sir Matthew Slattery, chairman of Short Brothers and Harland, explained that the Precision Engineering Division had been instituted, five years before, because the economy of Ulster favoured products with a high man-hour content; one object was to cultivate a team of engineers able to deal with the onerous problems involved in such products as guided weapons. The nucleus of that team had undertaken computer and simulator work for the aircraft division, and the support of the Castlereagh group had allowed the construction of a vertical take-off and landing project, heavily dependent on autostabilisation, to be undertaken. (In 1954 the research and development department of the Precision Engineering Division became the central research department of the whole company.)

The Minister, Mr. Aubrey Jones, recalling that 70 per cent of the share capital of the company belonged to the Government, stated that his attitude to the company was nevertheless that of a customer, and no orders were placed unless the terms offered were favourable. Moreover, it was now his policy that certain orders were not given to a firm unless it had not only the capacity to design, but also to produce, the required stores. This policy was reputed to favour the evolution of larger concerns and diminish the discrepancy between this country and the U.S.A. in the time taken to get into production. He did not think that the need for stronger units could justify nationalisation of the industry, and advocated rather diversification of activities as an insurance against the fluctuation of Government orders.

Utilising Natural Gas in Scotland

The supply of natural gas from a well sunk at Cousland, to the Musselburgh works of the Scottish Gas Board was inaugurated on Monday last, October 28, by Sir Harold Smith. The natural gas in the Cousland area has been formed in a bed of porous sandstone, which is sealed off by a dome of non-porous rock. To reach the average productive depth of the well a tube has been driven down some 1600ft and terminates at ground level in a 2in diameter tube surrounded by an 8¾in diameter casing. The natural gas has a pressure of 620 lb per square inch at the head of the well and its calorific value is about 930 to 960 B.Th.U. per cubic foot. From the well head the gas is taken by a high-pressure pipeline to a governor house, where the pressure is reduced in three stages to 3 lb per square inch, when it is delivered into a 4 miles long, 4in diameter main leading to the Musselburgh gas works.

At the works the pressure of the natural gas is further reduced to that of the coal gas being manufactured, before it joins the main coal gas stream. The coal gas normally produced at Musselburgh has a calorific value of 450 B.Th.U. per cubic foot, and this will be reduced by adjustments in the retort house to allow a proportion of natural gas with a calorific value of 960 B.Th.U. per cubic foot to be mixed with the coal gas, so that the gas produced for distribution will have the declared calorific value of 450 B.Th.U. per cubic foot. The reduction of the calorific value in the gas manufactured necessarily means that less coal will be used in its production, and it is calculated that 1 ton of coal will be saved at the Musselburgh works for every 7000 cubic feet of natural gas used.

Experimental Battery Railcar

At a press conference, held in Glasgow last week, the announcement was made of a projected experiment with an electric-battery-driven railcar on rural branch lines, which, it is thought, will have considerable possibilities in the lessening of the further closure of uneconomic branch lines in this country. For this experiment the British Transport Commission and the North of Scotland Hydro-Electric Board and two private engineering firms, Bruce Peebles, Ltd., and Chloride Batteries, Ltd., are to work in collaboration. It is expected that the new vehicle—a twin-coach battery-driven railcar—will be ready for service before next summer, and it is intended that initially it will run between Aberdeen and Ballater.

In outward appearance the vehicle, which will seat 117 passengers, will resemble the lightweight diesel trains already in service on British Railways, but the design has been modified to take the large batteries needed to operate the railcar throughout the day with only a short charge at the end of each trip. The batteries will be completely recharged during the night. Battery railcars have been in use in Germany for some years and advantage is being taken of experience in that country by the import of traction motors made by Siemens-Schuckert and electrical control gear by Schaltbau. For the experiment the North of Scotland Hydro-Electric Board will supply electricity at experimental rates for a period and will be responsible for the electrical feed equipment. Bruce Peebles, Ltd., will supply two glass bulb mercury arc rectifying charging plants, one to be situated at Aberdeen and the other at Ballater, whilst Chloride Batteries, Ltd., will provide the batteries for the vehicle.

Withdrawal of Offer to Build Nuclear Reactor

It was announced in London last week that Mitchell Engineering, Ltd., together with its American associates A.M.F. Atomics Inc., have withdrawn the offer to construct a 15MW boiling-water-reactor nuclear power plant for the Rheinisch-Westfalische Elektrizitätswerk, West Germany. The reason given was that the American company had been unable to agree with the U.S. Atomic Energy Commission on the financial terms with regard to the development of the proposed urania-thoria core of the reactor. Because of this, the associates had to offer an alternative core design. Had this revised offer been accepted, it is claimed, the reactor would have been guaranteed to reach criticality within the time originally specified, and to give the required net electrical output, all without increase in cost.

It had been planned to place preliminary orders in Germany for the reactor vessel, the heat exchangers, and the building of the whole containing structure. Apparently, however, certain contractual matters had not been resolved, particularly the Federal Republic's reported refusal to hold the contractors (A.M.F. Atomics Inc., Mitchell Engineering, Ltd., and Siemens-Schuckertwerke, Erlangen) free of liability for what is described as " nuclear incident."

We understand that the Rheinisch-Westfalische Elektrizitätswerk has asked the three contractors to submit an entirely fresh offer based on the new core proposals.

Sir Harry Railing

At his own request, Sir Harry Railing, D.Eng., has relinquished the offices of chairman and joint managing director of The General Electric Company, Ltd. He has taken an outstanding part in all the affairs of the company for nearly fifty-two years.

Sir Harry was trained as an electrical engineer on the Continent, and after receiving his degree of doctor of engineering spent some years acquiring further practical experience there and in the U.S.A. He joined the G.E.C. in 1905 to take charge of the test department and laboratories at Witton Engineering Works. Two years later, he joined Mr. Hugo Hirst (later Lord Hirst) in London as his chief technical adviser. In 1911, Sir Harry was made a director and placed in charge of the engineering works at Witton, where he remained for twenty years. In addition to these responsibilities he acted as the board's adviser on many problems arising from the company's widespread activities and became a director of many of the subsidiary undertakings. As a result, it became necessary for him to transfer his headquarters to London, so that in 1933 he left Witton, although he continued to control the engineering organisation. In 1941, Sir Harry became joint general manager of the company, and in the following year he was appointed vice-chairman, succeeding to the offices of chairman and joint managing director in 1943.

Sir Harry has held various positions in the Institution of Electrical Engineers for the last thirty-five years. He was elected chairman of the South Midland Centre in 1914 and served on the council for many years. He has also served almost continuously on the various Institution committees. He was elected a vice-president of the Institution in 1928 and became president in 1944. He was elected to honorary membership in 1953, and in 1955 he was elected president of the British Electrical Power Convention. Sir Harry is also chairman of the council of B.E.A.M.A., and a past-president of B.E.A.M.A. in 1952. In 1954 he was elected a vice-president of the British Electrical Development Association. He was knighted in 1944.

Mr. Leslie Gamage, who for some years has been vice-chairman and joint managing director of The General Electric Company, Ltd., has been appointed chairman and managing director. Sir Harry Railing will continue to serve on the board.

Theory of Shaft Whirling

No. IV—THE INFLUENCE OF ASYMMETRY IN BEARING CONSTRAINTS ON THE WHIRLING OF A SHAFT AND ROTOR

By E. DOWNHAM, B.Sc. (Eng.), Ph.D., A.F.R.Ae.S.*

(*Continued from page 591, October 25*)

The theoretical approach is here extended to include the case of a shaft carrying a symmetrical rotor of appreciable inertia, and supported by a bearing with unsymmetrical stiffness. The equation of motion for the critical whirling speeds is shown to have, in general, three real roots and one imaginary root, and for any given rotational speed there are four natural vibrations. Experiments are described in which measurements of critical speeds and natural vibrations were made. Good general agreement was obtained between theory and experiment as regards the real roots of the critical speed and natural vibration equations. A notable result of the comparison is that some of the measured natural frequencies appear to be associated with imaginary values of shaft speed and frequency. Also, whereas three real critical speeds are predicted by the theory, four critical speeds were obtained in practice. Thus a mathematically imaginary condition of whirling appears to manifest itself in a real form, for reasons not yet fully understood. A method for assessing the relative severity of critical whirling speeds is described which may achieve some economy in design.

IN the simple case of a cantilever shaft carrying a rotor of negligible moment of inertia at its free end, it has been shown previously[1] that if an additional flexible support having different stiffnesses in the horizontal and vertical directions is introduced near the rotor, two critical whirling speeds are obtained instead of the original one. In this simple case the critical speeds may be calculated by assuming equivalent symmetrical systems with flexible support having stiffness equal to the horizontal and vertical stiffness of the original support in turn. It should be remembered, however, that in the asymmetrical case, at speeds between the two critical speeds, the shaft whirls in the reverse direction to the rotation. The natural vibrations of a system of this kind are two in number, each associated with the stiffness in each of the two principal planes. The frequencies of the natural vibrations are constant and not affected by rotational speed.

When the moment of inertia of the rotor becomes appreciable, the whirling characteristics of the system are completely changed, to a greater extent even than in the symmetrical case treated in a previous article.[2] In this latter case it was shown that as the moment of inertia of the rotor increased, the critical speed also increased, although the effect was not great. But instead of one independent natural frequency, as in the simple case, the system was shown to have four natural circular vibrations, each varying with rotational speed.

In the following, a theoretical approach is described for the case of the cantilever shaft with rotor of appreciable inertia, when supported by a flexible outrigger bearing of asymmetric stiffness. Experiments are also described which were carried out on the model whirling rig, details of which were given in previous articles.[1, 2]

When applied to the model system used, the theory predicts three real critical speeds; the fourth root of the critical speed equation involves a negative value of Ω^2, representing an imaginary critical speed. Four critical speeds were, however, found in the experiments, three of which agreed with the three predicted. The fourth approximated to the numerical value of the imaginary theoretical speed. Many attempts have been made to reconcile this phenomena with the theory but without success. Unfortunately the author was not able to devote additional time to further experimental investigations of this, and the mystery is as yet unsolved. The agreement between the additional critical speed and the numerical value of the imaginary root may quite possibly be coincidental.

It was thought possible that the flexibility of the rotor arms may introduce an additional critical, although, the natural frequency of the non-rotating arm being 58 c/s and the critical speed being 26 c/s, it would be necessary to reconcile the phenomena with non-linear theory involving sub-harmonic resonances. However, brief checks were made on a modified rig with stiffened rotor arms and stiffer springs in the outrigger bearing. In this case the additional critical was not nearly as obvious as previously but, for all that, was still present. Similar effects were noticed when the natural frequencies were investigated. The theoretical variation of Ω^2 with ω^2 has two branches in the first quadrant and two branches one in each of the third and fourth quadrants, the latter representing imaginary values of ω and Ω. Measured natural frequencies agreed well with the two theoretical branches in the first quadrant but other natural vibrations were obtained which appeared to correspond numerically to the imaginary theoretical branches.

Apart from the appearance of the additional critical speed and natural vibrations, the results of the experiments were in good agreement with the real parts of the theory. One important conclusion was apparent from the calculations of whirl amplitudes in the range of shaft speeds embracing the critical speeds. Even when damping is omitted from the calculations it has been found that the calculated amplitude-frequency curves indicate the relative severity of the critical speeds. This makes predictions possible of the more dangerous critical speeds and those critical speeds near which it would be safe to operate.

THEORETICAL INVESTIGATIONS

The Whirling Condition.—Fig. 1 is a diagrammatic representation of the system in the whirling condition. OZ is the undeflected position of the shaft, O' the deflected position of the point of attachment O between rotor and shaft, and G the centre of gravity of the rotor. The mass of the rotor is m and its moments of inertia about its principal axes GA, GB, GC are a, a, c. Ω is the rotational speed of the shaft. The equations of motion are obtained by exactly the same analysis as that followed previously.[2] In the present case, however, the flexibility coefficients for the shaft are taken to be different in the X and Y directions, and the equations of motion (9), (10), (11), (12) of reference 2 thus become

$$X=-m[\ddot{X}-h\Omega^2\cos(\Omega t+\eta)]y_{11}-(a\ddot{\Phi}+c\Omega\dot{\theta})z_{11} \quad \ldots\ldots (1)$$

$$\Phi=-m[\ddot{X}-h\Omega^2\cos(\Omega t+\eta)]z_{11}-(a\ddot{\Phi}+c\Omega\dot{\theta})\phi_{11} \quad \ldots\ldots (2)$$

$$Y=-m[\ddot{Y}-h\Omega^2\sin(\Omega t+\eta)]y'_{11}-(a\ddot{\theta}-c\Omega\dot{\Phi})z'_{11} \quad \ldots\ldots (3)$$

$$\theta=-m[\ddot{Y}-h\Omega^2\sin(\Omega t+\eta)]z'_{11}-(a\ddot{\theta}-c\Omega\dot{\Phi})\phi'_{11} \quad \ldots\ldots (4)$$

in which X, Y, Φ, θ are the linear and angular displacements as in Fig. 1 and η is as before the angle between $O'G$ and GA; y_{11}, ϕ_{11}, z_{11} are now the flexibility coefficients pertaining to the direction of the X axis, and y'_{11}, ϕ'_{11}, z'_{11} those pertaining to the direction of the Y axis.

From equation (1) we have

$$-m[\ddot{X}-h\Omega^2\cos(\Omega t+\eta)]=\frac{X}{y_{11}}+(a\ddot{\Phi}+c\Omega\dot{\theta})\frac{z_{11}}{y_{11}}.$$

From equation (2) we have

$$-m[\ddot{X}-h\Omega^2(\cos\Omega t+\eta)]=\frac{\Phi}{z_{11}}+(a\ddot{\Phi}+c\Omega\dot{\theta})\frac{\phi_{11}}{z_{11}}$$

therefore

$$\frac{X}{y_{11}}+(a\ddot{\Phi}+c\Omega\dot{\theta})\frac{z_{11}}{y_{11}}=\frac{\Phi}{z_{11}}+(a\ddot{\Phi}+c\Omega\dot{\theta})\frac{\phi_{11}}{z_{11}},$$

i.e.

$$-(a\ddot{\Phi}+c\Omega\dot{\theta})\left(\frac{\phi_{11}}{y_{11}}-\frac{z_{11}}{y_{11}}\right)=\frac{\Phi}{z_{11}}-\frac{X}{y_{11}},$$

or

$$-(a\ddot{\Phi}+c\Omega\dot{\theta})=\frac{y_{11}}{\Delta}\Phi-\frac{z_{11}}{\Delta}X=\theta_{11}\Phi+\zeta_{11}X$$

where

$$\Delta=y_{11}\phi_{11}-z_{11}^2,\ \theta_{11}=\frac{y_{11}}{\Delta}\text{ and }\zeta_{11}=-\frac{z_{11}}{\Delta}.$$

Equation (1) may also be written as:

$$(a\ddot{\Phi}+c\Omega\dot{\theta})=-m\frac{y_{11}}{z_{11}}[\ddot{X}+h\Omega^2\cos(\Omega t+\eta)]-\frac{X}{z_{11}},$$

and equation (2) may be written as:

$$(a\ddot{\Phi}+c\Omega\dot{\theta})=-m\frac{z_{11}}{\phi_{11}}[\ddot{X}+h\Omega^2\cos(\Omega t+\eta)]-\frac{\Phi}{\phi_{11}}$$

therefore

$$-m\frac{y_{11}}{z_{11}}[\ddot{X}-h\Omega^2\cos(\Omega t+\eta)]-\frac{X}{z_{11}}=-m\frac{z_{11}}{\phi_{11}}[\ddot{X}+h\Omega^2\cos(\Omega t+\eta)]-\frac{\Phi}{\phi_{11}}$$

or

$$-m[\ddot{X}-h\Omega^2\cos(\Omega t+\eta)]\left[\frac{y_{11}}{z_{11}}-\frac{z_{11}}{\phi_{11}}\right]=\frac{X}{z_{11}}-\frac{\Phi}{\phi_{11}}$$

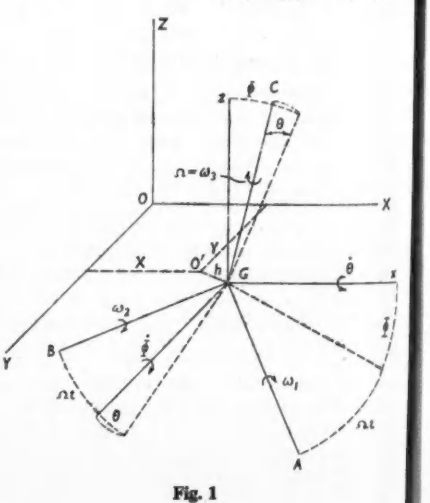


Fig. 1

* Principal Scientific Officer, Royal Aircraft Establishment, Farnborough.

therefore

$$-m[\ddot{X}-h\Omega^2\cos(\Omega t+\eta)]=\eta_{11}X+\zeta_{11}\Phi$$

where

$$\eta_{11}=\frac{\phi_{11}}{\varphi\Delta}.$$

Similar expression may be derived from equations (3) and (4).

We have therefore :—

$$-m[\ddot{X}-h\Omega^2\cos(\Omega t+\eta)]=\eta_{11}X+\zeta_{11}\Phi \quad . \quad (5)$$

$$-[a\ddot{\Phi}+c\Omega\dot{\theta}]=\zeta_{11}X+\theta_{11}\Phi \quad . \quad (6)$$

$$-m[\ddot{Y}-h\Omega^2\sin(\Omega t+\eta)]=\eta'_{11}Y+\zeta'_{11}\theta \quad . \quad (7)$$

$$-[a\ddot{\theta}-c\Omega\dot{\Phi}]=\zeta'_{11}Y+\theta'_{11}\theta \quad . \quad (8)$$

where

$$\theta_{11}=y_{11}/\Delta,\ \zeta_{11}=-z_{11}/\Delta,\ \eta_{11}=\varphi_{11}/\Delta$$
$$\text{and } \Delta=y_{11}\phi_{11}-z_{11}^2$$

and

$$\theta'_{11}=y'_{11}/\Delta',\ \zeta'_{11}=-z'_{11}/\Delta',\ \eta'_{11}=\varphi'_{11}/\Delta'$$
$$\text{and } \Delta'=y'_{11}\varphi'_{11}-z'^2_{11}$$

A particular solution to equations (5), (6), (7) and (8) is of the form

$$X=X_0\cos(\Omega t+\eta)$$
$$Y=Y_0\sin(\Omega t+\eta)$$
$$\Phi=\Phi_0\cos(\Omega t+\eta)$$
$$\theta=\theta_0\sin(\Omega t+\eta)$$

and substitution of these values in the above equations gives :—

$$(m\Omega^2-\eta_{11})X_0-\zeta_{11}\Phi_0=-mh\Omega^2 \quad . \quad (9)$$

$$-\zeta_{11}X_0+(a\Omega^2-\theta_{11})\Phi_0-c\Omega^2\theta_0=0 \quad . \quad (10)$$

$$(m\Omega^2-\eta'_{11})Y_0-\zeta'_{11}\theta_0=-mh\Omega^2 \quad . \quad (11)$$

$$-\zeta'_{11}Y_0+(a\Omega^2-\theta'_{11})\theta_0-c\Omega^2\Phi_0=0 \quad . \quad (12)$$

It will be noted incidentally that the above solution represents an elliptic form of whirl, as compared with the circular form obtained with symmetric bearing stiffnesses.

By elimination in equations (9), (10), (11) and (12).

$$F(\Omega^2)X_0=-mh\Omega^2[-m(c^2-a^2)\Omega^6+\{(c^2-a^2)\eta'_{11}-am(\theta_{11}+\theta'_{11})\}\Omega^4+\{a(\eta'_{11}\theta'_{11}+\eta'_{11}\theta_{11})-a\zeta'^2_{11}+c\zeta_{11}\zeta'_{11}+m\theta_{11}\theta'_{11}\}\Omega^2+\theta_{11}(\zeta'^2_{11}-\theta'_{11}\eta'_{11})] \quad . \quad (13)$$

and

$$F(\Omega^2)Y_0=-mh\Omega^2[-m(c^2-a^2)\Omega^6+\{(c^2-a^2)\eta_{11}-am(\theta_{11}+\theta'_{11})\}\Omega^4+\{a(\eta_{11}\theta_{11}+\eta_{11}\theta'_{11})-a\zeta^2_{11}+c\zeta_{11}\zeta'_{11}+m\theta_{11}\theta'_{11}\}\Omega^2+\theta'_{11}(\zeta^2_{11}-\theta_{11}\eta_{11})] \quad . \quad (14)$$

where

$$-F(\Omega^2)=m^2(c^2-a^2)\Omega^8+\{(a^2-c^2)(\eta_{11}+\eta'_{11})+am^2(\theta_{11}+\theta'_{11})\}\Omega^6+\{am[(\zeta^2_{11}+\zeta'^2_{11})-(\theta_{11}\eta'_{11}+\theta'_{11}\eta_{11}+\eta_{11}\theta_{11}+\theta'_{11}\eta'_{11})]+(c^2-a^2)\eta_{11}\eta'_{11}-m^2\theta_{11}\theta'_{11}\}\Omega^4+\{(m\theta'_{11}+a\eta'_{11})(\theta_{11}\eta_{11}-\zeta^2_{11})+(m\theta_{11}+a\eta_{11})(\theta'_{11}\eta'_{11}-\zeta'^2_{11})\}\Omega^2-(\eta_{11}\theta_{11}-\zeta^2_{11})(\eta'_{11}\theta'_{11}-\zeta'^2_{11}) \quad . \quad (15)$$

The critical whirling speeds (at which X_0, Y_0 become infinite) are obtained from

$$F(\Omega^2)=0 \quad . \quad (16)$$

a quartic in Ω^2 with, in general, four roots.

The Natural Vibrations of the Rotating System.—The natural vibrations are obtained from equations (5), (6), (7) and (8) by adopting a solution of the form

$$X=X_0\cos(\omega t+\eta)$$
$$Y=Y_0\sin(\omega t+\eta)$$
$$\Phi=\Phi_0\cos(\omega t+\eta)$$
$$\theta=\theta_0\sin(\omega t+\eta)$$

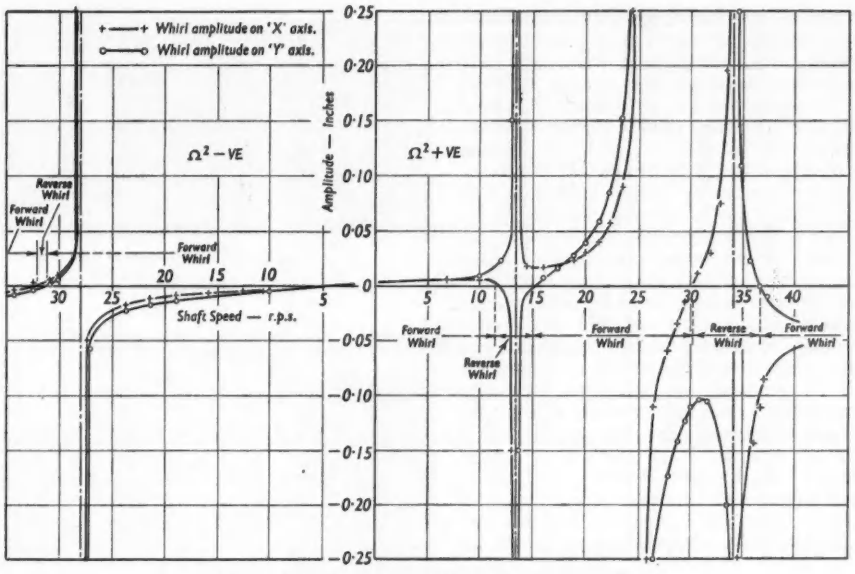


Fig. 2—Calculated whirl amplitude-frequency curves (Case I)

and putting $h=0$, giving a frequency equation of the form :—

$$[(m\omega^2-\eta_{11})(a\omega^2-\theta_{11})-\zeta^2_{11}][(m\omega^2-\eta'_{11})(a\omega^2-\theta'_{11})-\zeta'^2_{11}]-c^2\Omega^2\omega^2(m\omega^2-\eta'_{11})(m\omega^2-\eta_{11})=0 \quad . \quad (17)$$

For a given value of Ω, this equation represents a quartic in ω^2, with, in general, four roots.

Equation (17) may be written in the form

$$\Omega^2=\frac{[(m\omega^2-\eta_{11})(a\omega^2-\theta_{11})-\zeta^2_{11}][(m\omega^2-\eta'_{11})(a\omega^2-\theta'_{11})-\zeta'^2_{11}]}{c^2\omega^2(m\omega^2-\eta_{11})(m\omega^2-\eta'_{11})} \quad . \quad (18)$$

Calculated Results for the Experimental System

Using equation (16) in conjunction with the details of the system given below, the critical whirling speeds were calculated for maximum rotor inertia. The elliptic whirl amplitudes X_0 and Y_0 were found for particular rotational speeds from equations (13) and (14). A representative value of h was used and amplitude frequency curves plotted in Fig. 2. Values of X_0 and Y_0 obtained for negative values of Ω^2 are also included. The natural vibration frequencies for particular rotational speeds were obtained by substituting particular values of ω^2 in equation (18) and evaluating for Ω^2. The results are given directly in Fig. 3 as a plot of Ω^2 against ω^2.

Throughout the calculations a correction was made for the flexibility of the rotor arms. The correction was the same as that applied to the symmetrical system.[2, 3]

Details of the Experiments

The model rig described previously,[1, 2, 3] was used for the experimental investigations. The shaft used was ¼in diameter and 12in long, and was operated as a cantilever with a flexible outrigger bearing placed 10in from the fixed end. The two horizontal springs supporting the outrigger bearing were made appreciably stiffer than the two vertical springs, the lower natural frequency of the non-rotating system being 26·2 c/s in the horizontal direction and 20·4 c/s in the vertical direction. Whirl forms and amplitudes at the free end of the shaft were recorded photographically, and shaft speeds were recorded electronically and synchronised with the recordings of whirl forms. The spring constants of the system were obtained by direct loading, and the

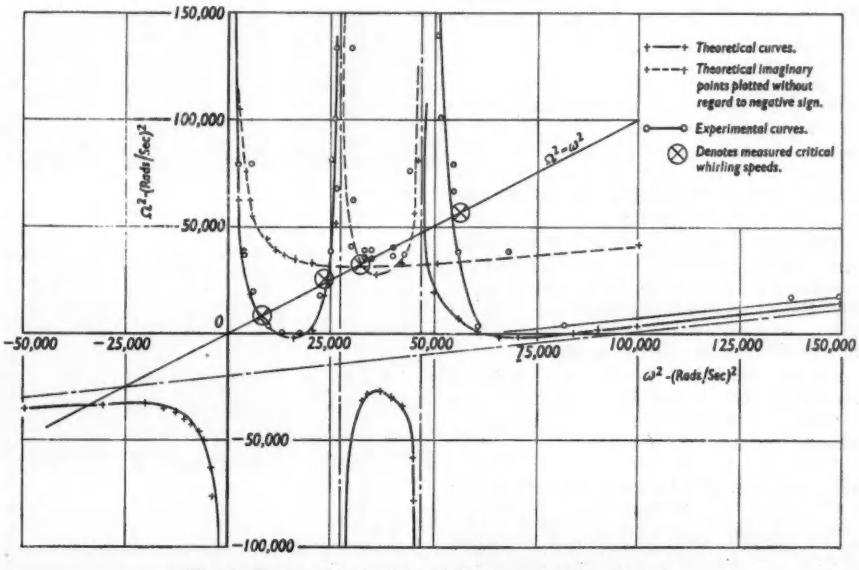


Fig. 3—The natural vibrations of the rotating system (Case I)

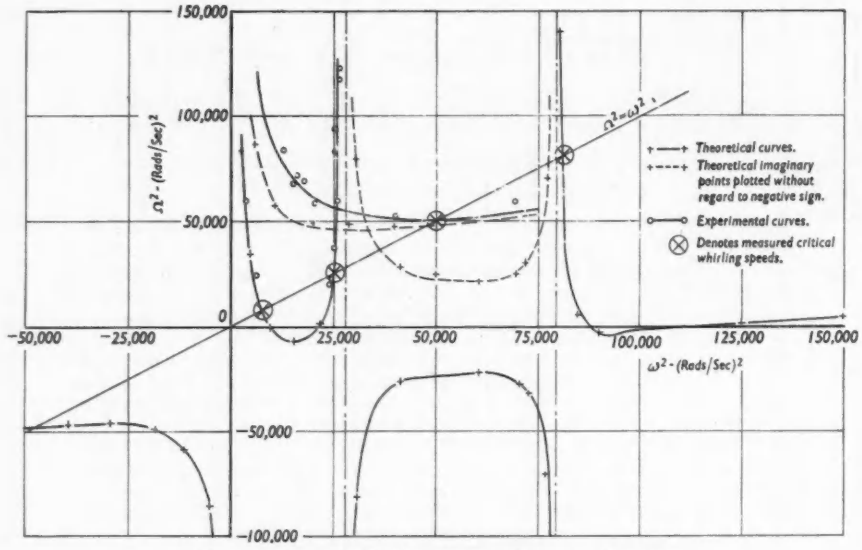


Fig. 4—The natural vibrations of the rotating system (Case II)

flexibility coefficients were deduced from these measurements. Dimensional details are given in Tables I and II.

TABLE I—*Dimensional Details of the Experimental Rig (Case I)*

Effective length of shaft	12in
Distance of outrigger bearing from the fixed end of the shaft	10in
Equivalent weight of shaft	0·044 lb
Weight of rotor	0·888 lb
Hence equivalent end load	0·932 lb and m=0·00239 lb in sec²
Moments of inertia of rotor	C=0·0552 lb in sec², a=0·0251 lb in sec²
Measured spring rate of outrigger bearing support	(Horizontal)=126·5 lb/in
Measured spring rate of outrigger bearing support	(Vertical)=51 lb/in

Flexibility coefficients

Horizontal	Vertical
y_{11}=0·0144	y'_{11}=0·0271
z_{11}=0·00266	z'_{11}=0·00415
ϕ_{11}=0·00098	ϕ'_{11}=0·00115
$\left(\phi_{11}+\frac{\mu_{11}}{2}\right)$=0·00131	$\left(\phi'_{11}+\frac{\mu_{11}}{2}\right)$=0·00148
$\Delta=y_{11}\left(\phi_{11}+\frac{\mu_{11}}{2}\right)-z^2_{11}$	Δ'=0·0000229
=0·00001179	
θ_{11}=1220	θ'_{11}=1183
η_{11}=111	η'_{11}=64·63
ζ_{11}=−225·4	ζ'_{11}=181·2

TABLE II—*Dimensional Details of Revised Model Rig (Case II)*

Effective length of shaft	12in
Distance of outrigger bearing from the fixed end of the shaft	10in
Equivalent weight of shaft	0·044 lb
Weight of rotor	0·986 lb
Equivalent end load	1·03 lb therefore m =0·00267 lb in sec²
Moments of inertia of rotor	C=0·0584 lb in sec², a=0·0268 lb in sec²

Flexibility coefficients

Horizontal	Vertical
y_{11}=0·01076	y'_{11}=0·02997
z_{11}=0·002125	z'_{11}=0·00439
ϕ_{11}=0·00093	ϕ'_{11}=0·001185
η_{11}=212	η'_{11}=73
θ_{11}=2301	θ'_{11}=1845
ζ_{11}=−511	ζ'_{11}=−270

THE CRITICAL WHIRLING SPEEDS OF THE SYSTEM

From measurements of whirl amplitudes and shaft rotational speeds, amplitude-frequency curves pertaining to deflections in the X and Y directions have been plotted (Fig. 5) showing the critical speeds and directions of whirl of the system for maximum rotor inertia. In Fig. 6 a series of records is shown, demonstrating the nature of the shaft whirl forms at different speeds within the critical speed range.

THE NATURAL VIBRATIONS OF THE ROTATING SYSTEM

The rotating shaft was excited by means of a motor-driven crank elastically coupled to the shaft. An inductance-type proximity pick-up was used to investigate the resonant frequencies of the shaft. These frequencies were obtained at various speeds of shaft rotation by running the shaft at a particular speed and exciting it over the frequency range of the exciter, the resonant frequencies being observed visually on a monitor C.R.T. and then recorded on film to give an exact frequency reading. The range of shaft speeds over which investigations were carried out was chosen to cover speeds from zero revolutions per minute to a value well above the highest critical whirling speed of the shaft. The results of these experiments are shown plotted in Figs. 3 and 4.

DISCUSSION OF THE RESULTS

The Critical Whirling Speeds.—For the shaft rotor system investigated there are three positive roots (in Ω^2) of equation (16), and one negative root, from which it may be assumed that there should be three real critical whirling speeds. Allowing for flexibility of the rotor arms, the calculated critical whirling speeds for the system are 13·4, 25 and 34·3 r.p.s. respectively. The negative root of the equation gives a value for Ω^2 of −31300 (rad./sec)², which is equivalent to an imaginary critical speed of 28 c/s, and theoretically will not appear as a true critical speed. In Fig. 2 calculated values of the elliptic axes in the X and Y directions are plotted for rotational speeds up to 45 c/s, which covers the critical speed range of the system. The direction of whirl of the shaft is established from the relative signs of X and Y, i.e. when X and Y have the same sign the shaft will whirl in the direction of rotation, and when X and Y have opposite sign the shaft will whirl in the reverse direction to the rotation. It is seen from Fig. 2 that, this being the case, the first and third criticals will be reverse whirls, and the second critical a forward whirl, there being rotational speeds between the criticals at which the vibratory motion of the shaft is linear in either X or Y directions.

Fig. 5 shows the measured values of the elliptic amplitudes of whirl in the X and Y directions. It is seen that there are in this case four critical whirling speeds, of which the first, second and fourth correspond to the calculated real critical speeds occurring at 13·8, 23·5 and 37 c/s respectively, whilst the third measured critical speed occurs at 28·7 c/s, which is very near the numerical value of the calculated imaginary critical speed. The observed directions of whirl of the shaft at the first, second and fourth critical speeds are the same as those estimated theoretically. At the third critical speed the shaft is observed to whirl in a forward direction, resulting in six changes of direction of whirl of the shaft within the critical speed range, instead of the four changes anticipated from the theoretical curves of Fig. 2. The stiffness and inertia constants of the system were changed to see whether this extra critical speed was a result of a particular combination of such constants; but in all cases, within the limits of the rig, the third critical speed was found to be present. The correction in the calculations for the flexibility of the rotor arms improves the calculations at the lower frequencies, but over-corrects the calculations at the higher frequencies, i.e. when the frequencies approach the natural flexural frequency of vibration of the rotor arms.

Referring to Fig. 5, it is apparent that, although there are four critical whirling speeds, in only one case (i.e. the second critical) did the rotor whirl with sufficient amplitude to strike the guard ring; in all other criticals the amplitude of whirl was well within the limits of the allowable

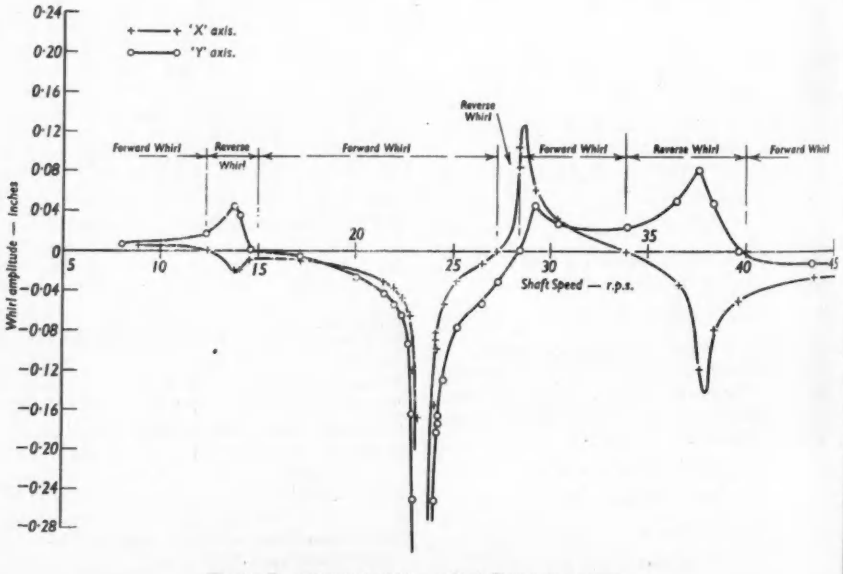


Fig. 5—Experimental whirl amplitude/frequency curves

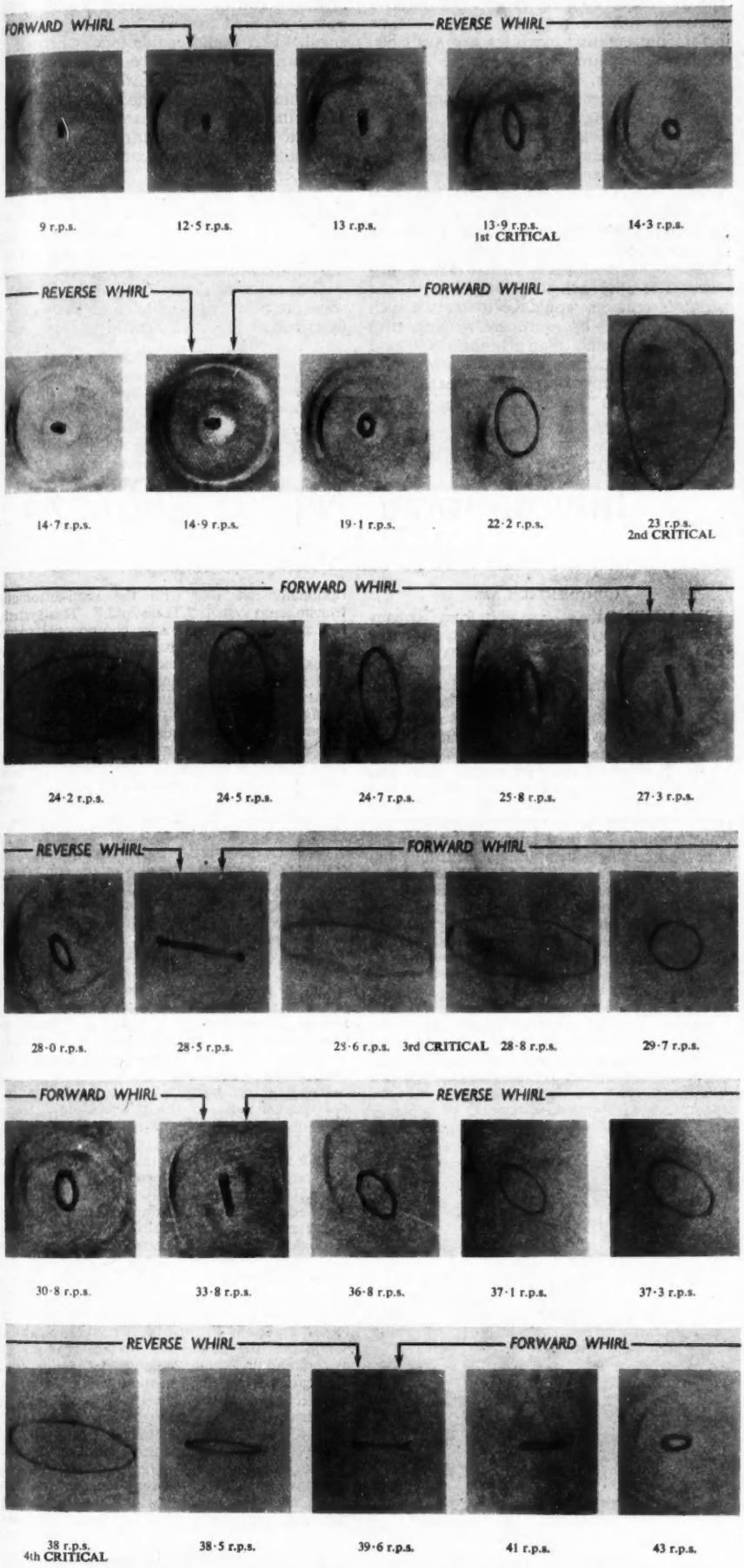


Fig. 6—Records of whirl patterns at various speeds of rotation of a shaft carrying a rotor of appreciable inertia supported by a bearing of unsymmetrical stiffness

maximum amplitude, especially in the case of the first critical, at which the amplitude of whirl was almost negligible. It appears, therefore, that in unsymmetrical systems of this kind, although theoretically there will be a number of critical speeds within a relatively small speed range, certain of the critical speeds will give rise to more severe stresses in the system than others. It will consequently be of greater importance to avoid these criticals even at the cost of running at speeds corresponding to the minor criticals.

In Fig. 2 the theoretical whirl amplitude frequency curves may be compared with the first, second and fourth critical speeds obtained experimentally and indicated by Fig. 5. Although the curves of Fig. 2 have been calculated assuming no damping in the system, it is apparent that the second critical is likely to give rise to the most severe stresses on the system, and in comparison the first critical is relatively insignificant. These facts are in agreement with those drawn from the experimental curves. The application of this technique in the design stage of a complex system will therefore enable the relative severity of the critical whirling speeds to be obtained without actually running the system. With experience it may even be possible to ignore certain of the critical speeds (as would have been possible in the case of the first critical in the above system), thus simplifying the design considerations regarding the whirling characteristics of the proposed system.

The Natural Vibrations of the Rotating System.—Fig. 3 shows both theoretical and experimental curves of Ω^2 and ω^2, Ω being the rotational speed of the shaft and ω the frequency of natural vibrations. The theoretical curve is extended over both positive and negative values of ω^2. As far as values of Ω and ω are concerned, the curve has two "real" branches (in the first quadrant) and two "imaginary" branches in the third and fourth quadrants. Experimental results, which are, of course, located only in the first quadrant, agree well with the theory in the case of the two theoretical real branches. Additional experimental results were, however, obtained which appear to be dissociated from these branches. These additional results do, however, lie close to curves (shown dotted in Fig. 3) which are reflections of the theoretical imaginary branches into the first quadrant or re-plots of the imaginary branches with positive signs throughout.

Critical whirling conditions are obtained whenever the rotational speed of the shaft equals the frequency of natural vibration and are therefore given in Fig. 3 by intersections of the line $\Omega^2=\omega^2$ with the curve $\Omega^2 \sim \omega^2$. The first, second and fourth measured critical speeds are seen to correspond to the intersections with the two theoretical real branches. The third measured critical speeds, for which there is no theoretical real counterpart, could be associated with the reflections into the first quadrant of either of the two theoretical imaginary branches. For the system of Fig. 3 it therefore appears that, in respect both of natural frequencies and critical speed, the experimental results dissociated from theoretical real values might be associated with either of the two reflected theoretical imaginary branches.

In an attempt to throw further light on this aspect, the rig was modified by increasing the stiffness of the rotor arms (making a correction for rotor arm flexibility unnecessary) and increasing the stiffness of the horizontal springs in the outrigger bearing. The theoretical and experimental results of these repeat experiments for natural frequencies and critical speeds are given in

Fig. 4. Referring to Fig. 4, it is seen that in the relevant portion of the diagram there is now a greater separation between the two reflected theoretical imaginary branches, and the experimental results dissociated from theoretical real values are in this case associated with the reflected theoretical branch from the third quadrant rather than with that from the fourth quadrant. In this case, however, the fourth critical was not nearly as apparent as in the first case nor were the unexpected natural vibrations.

Conclusions

Agreement between theory and experiment has been found to be very good as regards the real parts of the theoretical approach. The reason for the appearance of theoretically imaginary vibrations as real quantities in practice is not readily understood, and only experience of these effects on a similar full-scale installation will indicate whether it is necessary to ignore them in design calculations. The method described for assessing the relative importance of the critical whirling speeds is felt to be important for application in the design stage of practical systems, as experienced application of the method may enable certain of the critical speeds to be ignored and thereby avoid unnecessary modifications to the design.

The results of the experiments described in this series of articles show that, in general, there is a good agreement between theory and experiment. The use of small model rigs for theoretical investigation has proved satisfactory, although the results of the preliminary experiments with the simpler shaft rotor configuration does emphasise the need for careful design of rig to eliminate non-linear effects, such as friction fits and unwanted bearing constraints. However, the advantage of the model system lies in the ease with which the important parameters can be varied and the basic system simplified to enable these unpredictable effects to be investigated and allowed for in the more complex experiments. Although the experiments have proved the validity of the theoretical approach, they have also shown clearly that notwithstanding the accurate theory there are still important factors to be reckoned with before accurate calculations of critical speeds can be made. Probably the most important of these factors is the estimation of the rotor inertia characteristics and shaft stiffness coefficients. Modern techniques for the construction of electrical and turbine machinery involving large continuous loads of complex construction between bearings make allowance for inertia effects difficult, as inertia is only effective where the shaft whirling form has other than zero slope, and the magnitude of the effect is related to the slope of the shaft. In such cases it is necessary to assume a number of disc loads instead of continuous loading, but even then it is almost impossible to calculate the whirling form of such a system. Even more important is the calculation of deflection coefficients involving a knowledge of the stiffness of the rotor, which in many cases contributes largely to the effective stiffness of the system.

It is becoming apparent amongst designers of machinery of this kind that the only way to more accurate estimates of critical speed in the design stage must lie in a semi-empirical approach to the estimation of these parameters. This in itself is not easy, as design trends, particularly for gas turbines, have changed rapidly in the last few years and there is insufficient background of experience. Without this empirical knowledge it will continue to be difficult to design for critical speeds outside running range, and curative measures will be required for some time before preventative measures are available. Curative measures in themselves present many difficulties. Here the designer is faced with the prospect of lengthy experiments on test beds, trying modifications which are often expensive in time and money. The author's experience with gas turbine manufacturers has been that this kind of investigation is seldom popular, as test bed programmes are so crowded as to obviate the inclusion of tests which may lead to damage to expensive and not easily replaceable parts of an engine, particularly turbine blades. The alternative approach to gas turbines, in the author's opinion, would be to replace such things as blades by equivalent weights, strip off expensive combustion chambers and drive the remaining carcase, which is essentially of the same dynamic stiffness, by means of an external motor. Providing that the whirling system is run in an evacuated chamber, the power required to drive would be relatively small. This would enable quick changes to the bearing supports to be made, of a relatively crude construction, which would point to the final design requirements.

Another important factor affecting the accurate calculation of critical speed is the constraint arising from bearings, particularly plain bearings.

Following the experiments already described, the author carried out a series of tests on a larger rig to demonstrate the nature of these constraints and their effect on the critical whirling speed of a simple system.

The results of these experiments, which in some respects are quite unique, will be described in the next article in this series.

References

[1] The Engineer, October 11, 1957, pages 518–522.
[2] The Engineer, October 18, 1957, pages 552–555.
[3] The Engineer, October 25, 1957, pages 588–591.

(*To be continued*)

International Motor Show

No. III—(*Concluded from page 601, October 25*)

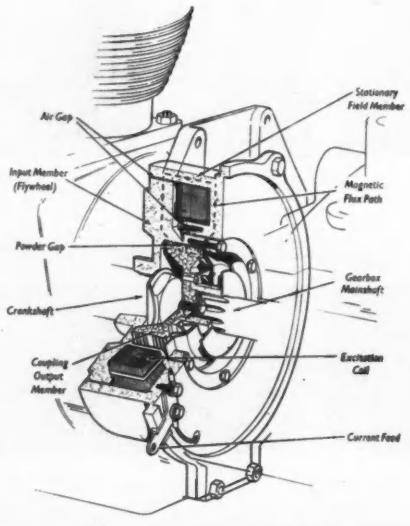
Continental Cars

EXAMINING the other exhibits from Germany and Italy, we note that, apart from the new Fiat "500" and such models which have already been described in some of our recent reports, the general design has remained practically static and that constructional changes are confined to detail modifications. There are, however, some interesting innovations among the French exhibits which should be noted.

The Panhard "Dyna" front-wheel drive car, powered by a horizontally opposed 850 c.c. two-cylinder engine (characterised by its ingenious valve operating gear, employing torsion bar valve springs) has been improved by adopting a new air cooling system, using a centrifugal fan and cowled cylinders. By these means it has been possible to increase the output of the engine, which, in the sports version fitted to the D.B. rally saloon, now develops 55 h.p. at 5700 r.p.m. with a compression ratio of 8 : 1. All Panhard cars are optionally available with two-pedal control of the "Selectroshift" system made by Jaeger, the French associate of Smiths, of England.

Displayed at the stand of Renault, Ltd. (the British assembly works of the Paris firm) was the 2·14-litre, four-cylinder saloon "Frégate," practically unchanged since last year's show, but now optionally available with the semi-automatic transmission system "Transfluid." This system, in the arrangement of its main components, somewhat resembles the Mercedes "Hydrac" transmission presented in the 2·2-litre cars of this firm at the recent Frankfurt motor show. It consists of three basic units, a hydraulic drive, a single dry-plate separating clutch, and a three-speed gearbox, synchronised in all forward ratios and having a constant-mesh reverse gear. The main difference between the two systems concerns the hydraulic part, which, in case of the "Hydrac," is a fluid coupling without any torque multiplication, while that of the "Transfluid" system is a three-element torque-converter with a maximum conversion ratio of 2·2 : 1. This converter is of conventional design, comprising a pump, a turbine, and a reaction member which is free to rotate in the same direction as the turbine, but is locked by a freewheel device against rotation in the opposite direction. Another difference between the two systems is the design of the clutch withdrawal mechanism, which, in the Mercedes transmission, is vacuum operated, while that of Renault is actuated by a solenoid, connected to a button on the gear-change lever. The re-engagement of the clutch, however, is in both cases effected by vacuum from the inlet manifold.

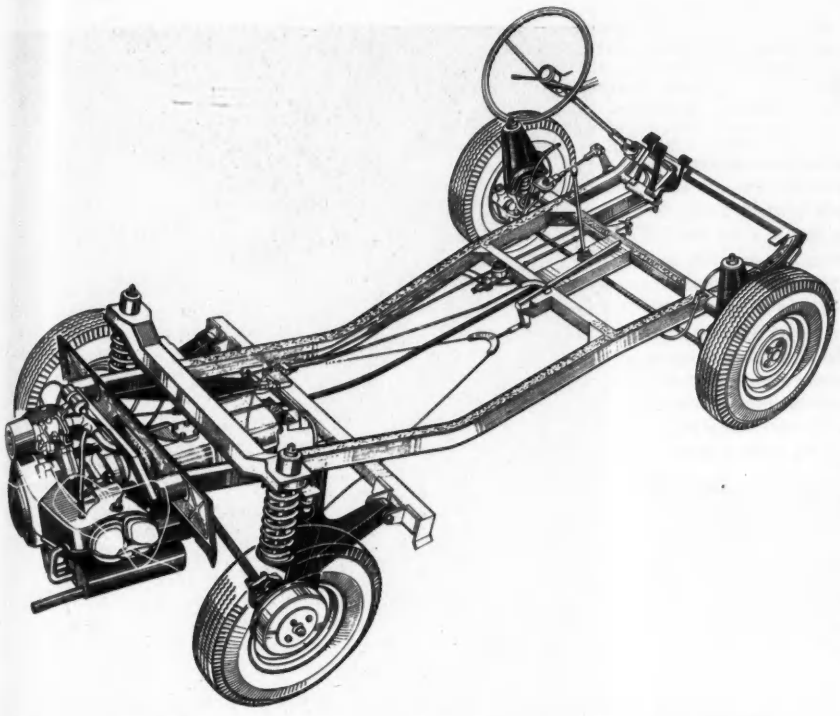
It will be seen from this short description that the characteristic of the "Transfluid" transmission must differ considerably from that of the "Hydrac" drive. The fluid coupling of the latter system serves to take up the drive from rest, and, at an engine speed in excess of 1600 r.p.m., operates practically without slip; the required torque variations are effected by mechanical means, i.e. with high overall efficiency through the manual selection of the appropriate gear ratio. The "Transfluid" drive, on the other hand, relies over a wide range of operating conditions on the torque multiplication of the hydrodynamic converter—at the expense of losses, especially in the higher conversion ratios—and uses the second and bottom gear mainly as "mountain" and "emergency" ratios. All gear ratios are selected in the orthodox way, i.e. by mechanical links between the gearbox and the gear-shift lever at the steering column. An indicator with six stops underneath the steering wheel shows which gear ratio is engaged; there is also an additional "parking" stop in which position the transmission is positively locked to supplement the hand brake if the car is left stationary on a gradient.



On the "Isetta" the Smiths magnetic coupling has stationary field windings, dispensing with brush gear

American Cars

The American motor manufacturers were again represented at this year's show in strength. Not less than sixteen firms displayed an impres-



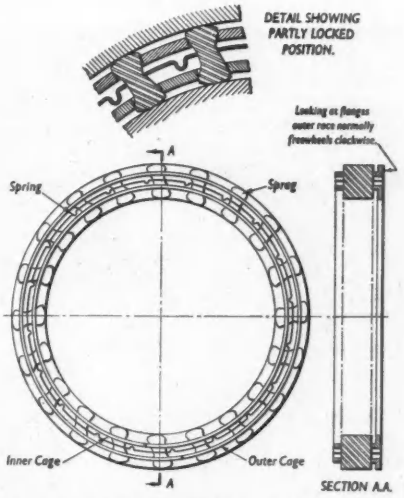
The chassis of the B.M.W. "600" shows the simplicity possible with Dubonnet suspension

sive collection of mainly new models from U.S.A. and Canada, intended not for sale here, but in such overseas countries as have no import and currency restrictions. One of their characteristics is, metaphorically speaking, their almost uniform appearance, which sometimes makes it difficult to distinguish between the various makes. A closer inspection of the exhibits does not help to clarify matters very much, for in the absence of demonstration models and, also, because of the lack of information at the dealers' stands, it is not easy to assess their technical details.

American constructional principles in the past had and are still having considerable influence on the British and Continental detail design ; on the other hand, U.S.A. motor manufacturers are now mainly concerned with designs to suit the taste and the requirements of the domestic market (leaving it to their European associates to supply such vehicles as do not conform to their conception), so that less and less of these principles can usefully be embodied in the layout of new European models. There can be no doubt about the skill of the American designer nor about the extensive work which is going on in the research and development centres of the big American motor manufacturing companies. The reason that the results of their technical ingenuity seem to be less apparent than those of their European colleagues, is the emphasis which the the American manufacturers place on styling. As technical perfection is almost taken for granted, it is obvious that, in the highly competitive American market, the main aim of the manufacturers is to stimulate additional demand by the annual creation of new and startling body styles. For this reason the average visitor or even the expert, when looking at the American models displayed at the show, is frequently unable to fully appreciate the finesses of American detail design, and is inclined to regard the latest U.S.A. models not so much as functional engineering products, but as the creations of body stylists eager to promote new fashion trends. Even if one does not entirely share this opinion, it is difficult to see any major technical modifications incorporated in American cars since last year's show, which, in view of our restricted space, would justify more than a few short notes. Further, it must be borne in mind that most of the American 1958 models will not make their public appearance until later this year, and that such much-discussed features as the new air suspension and the fuel injection developed by General Motors will be shown on this occasion.

The only American make not previously shown at Earls Court was the Edsel, a product of the Ford Motor Company, represented by four models. The biggest of them was the 1958 Edsel "Citation," a four-door, hard-top saloon, having a wheelbase of 10ft 4in and an overall length of 18ft 3in. This car has a 345 h.p., 6·72-litre, vee eight-cylinder engine with the high compression ratio of 10·5 : 1 ; it develops a maximum torque of 475 lb-ft at 2900 r.p.m.

Displayed at the same stand was a 1957 Ford "Fairlane" Skyliner hard-top convertible, which, introduced since the last show, has not been seen before in this country. The "Fairlane" range, Ford's best seller this year in U.S.A., is a typical example of contemporary American automobile design, having a very stiff orthodox chassis with a coil-sprung wishbone type front suspension and a live rear axle with semi-elliptic leaf springs. The smallest engine is a 4·8-litre vee-eight with a two-barrel carburetter which, at a compression ratio of 9·1 : 1, develops 212 h.p. at 4500 r.p.m. The car, which is roomy even by American standards, has a wheelbase of 9ft 10in, an overall length of 18ft 2in, and a height of 6ft 5in. The well-styled and lavishly equipped exhibition model is particularly interesting, in that the hard top is electrically retracted and, at the touch of a button, disappears beneath the boot lid ; this operation takes less than a minute each way. The boot is sufficiently large to provide ample luggage space even with the hard top stowed away ; when the roof is raised considerably more luggage can be carried. A wide range of optional equipment is available—for instance, a vacuum booster fuel pump, power brakes and power steering, electric window lift, and electric four-way adjustment of the front seats. The choice of engines includes a 300 h.p. supercharged "Thunderbird" and of transmissions the water-cooled "Fordomatic."

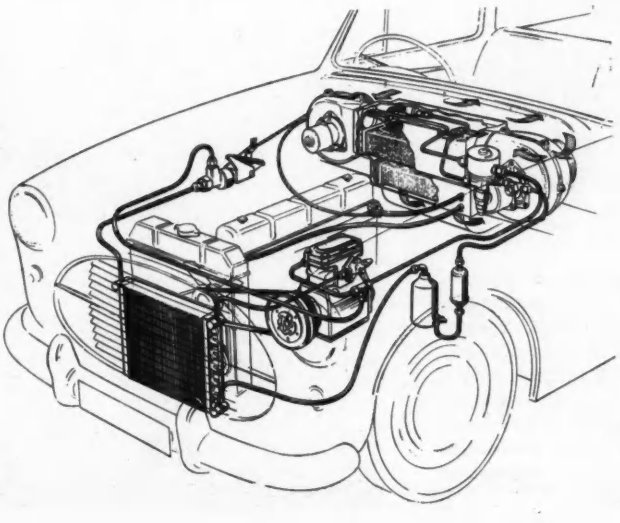


The sprags of the Borg-Warner one-way clutch are fully phased by concentric cages

An example of General Motors' products is the 1957 Buick "Century," equipped with a vee-eight, 6-litre engine which develops 300 h.p. at 4600 r.p.m. An interesting feature of this car is the new "Dynaflow" transmission, characterised by a torque converter having a variable-pitch stator in conjunction with a two-speed epicyclic gear. The "Century" is the only G.M. product to use coil springs at the front and at the rear, and a torque tube drive.

The Dodge "Kingsway-Custom," a four-door saloon, has a 5·34-litre vee eight-cylinder engine with a compression ratio of 10 : 1, which develops 290 h.p. at the remarkably high speed of 5300 r.p.m. The car has torsion bar suspension with rubber-mounted ball joints at the front and, at the rear, semi-elliptic leaf springs which are mounted outside the frame length members. It is equipped with an automatic transmission incorporating a torque converter and a three-speed epicyclic gear operated by push button selector mounted on the facia panel.

Centre of attraction at the stand of U.S. Concessionaires, Ltd., was the Pontiac "Club de Mer," an experimental two-seater sports car,

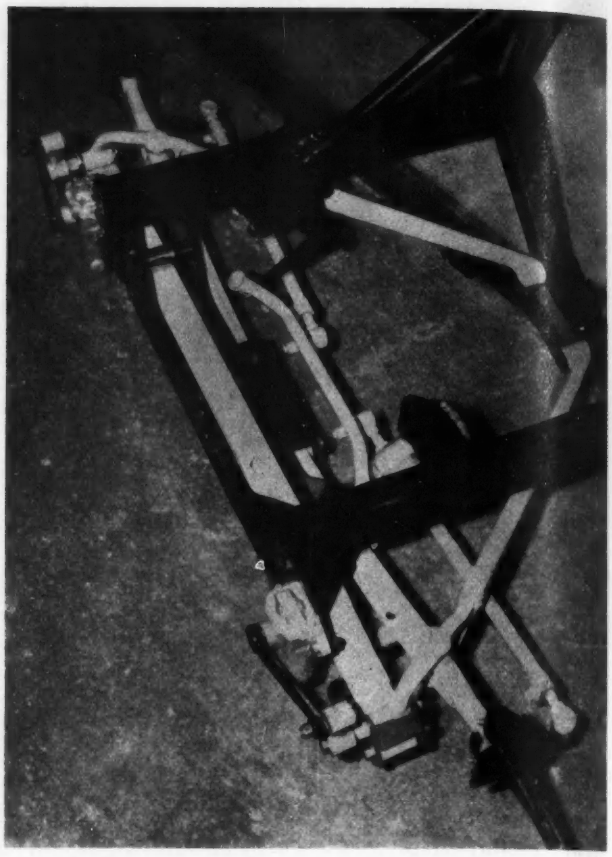


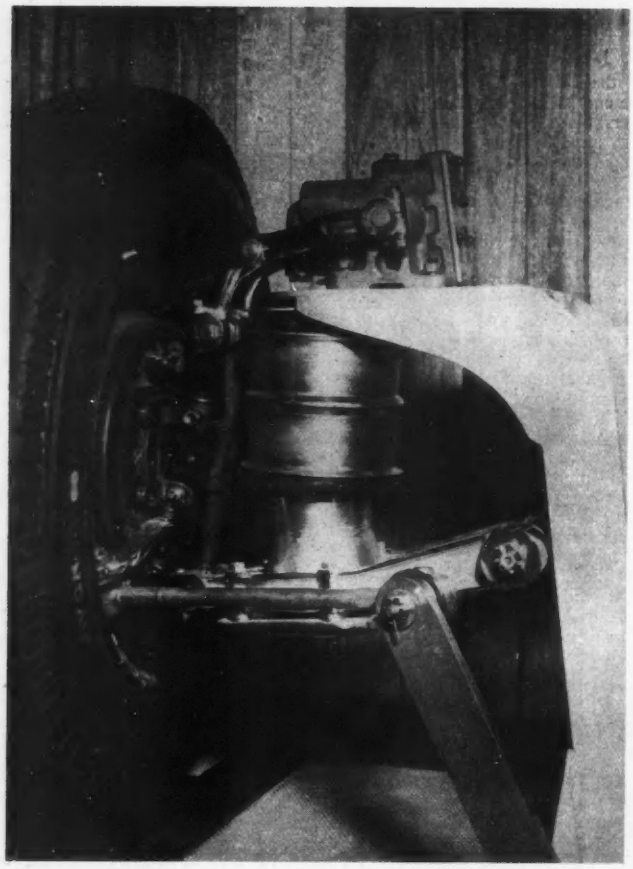
Starting at the front of the car and moving in a clockwise direction, the components are as follows : mounted directly in front of the cooling system radiator is the condenser ; next is the modulator valve which regulates the quantity of the refrigerant fed to the compressor, while behind the engine and mounted against the bulkhead are the two blower units, one for drawing in fresh air from outside the car and one for recirculating air already present inside the car. In between the blowers is the evaporator and heater unit. In front of the near side blower can be seen the throttling valve which reduces the pressure of the refrigerant before feeding it to the evaporator, and just above the near side front wheel are the receiver and drier units. Alongside the engine can be seen the compressor, belt-driven from the engine fan pulley.

The Smiths air conditioning equipment as it would be installed

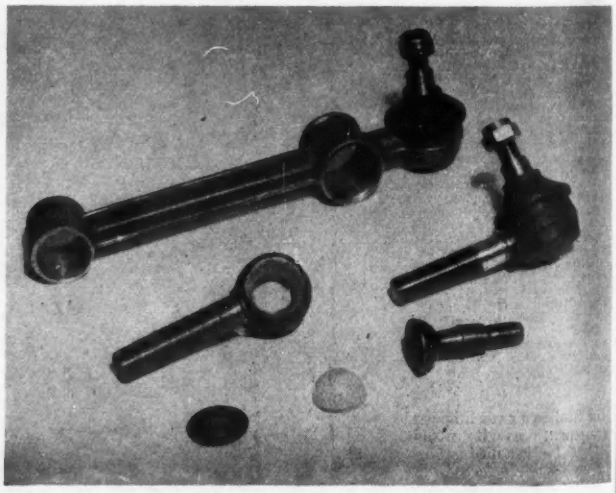
Suspension Developments

The swing axle suspension of L.M.B. Components, Guildford, in the form seen at the Show, could be incorporated in the Ford " Popular," and exhibits a refined simplicity appropriate to the car. In order to allow the utmost exploitation of the high tractive effort of a torque tube drive, the roll stiffness at the front has been increased out of proportion to the suspension frequency by a four-point location of the spring which resists asymmetrical deflection ; the actual detail of the two inner points is ingenious, the spring passing between pairs of rubber-bushed sleeves that locate it without constraining its slope. The loss of cornering power that might be expected from the increased weight transfer is overcome by the use of short swing axles, developing a significant change of camber which acts to reduce the slip angles. The precession couples associated with rapid changes in camber are mitigated by the very direct and stiff linkage between the two rotating masses, and the movement of the steering linkage in response to the residual impulse is minimised by the use of a hydraulic damper as the slave arm pivot ; this damper has no influence at the slow rates of displacement that can be developed by the driver, but resists movement at the high velocities at which inertia coupling can become important. While only grease-lubricated ball joints are interposed between the steering arms, the centre track rod is carried on rubber bushes, the torsional strain of which gives a faint spring action towards the straight-ahead attitude. A modified version of this suspension is to be produced for conversion of existing beam-axle cars.





The Andre air spring, seen at the left as it might have been applied to the Standard front suspension, is built under licence to the General Tire and Rubber Company of the United States. The piston is so contoured as to modify the rate of change of volume throughout the stroke and thus allow a soft ride without extreme impact and rebound travels. The change in angular attitude between piston and cylinder is, however, unusually pronounced. While not novel, the use of the entire piston as part of the working volume is noteworthy. In order to save air and avoid the complication of delay relays, the self-levelling system will, it is proposed, act only when the doors of the car are open. To match the increased suspension movements available with a load-compensated suspension, specially developed rubber bushes are used at the inner ends of the lower wishbones. The bushes are made in this country by Silentbloc, Ltd., on whose stand both these exhibits were displayed.



The steering ball joint seen is packed with grease on assembly and needs no further lubrication throughout its life ; it is an interesting contrast to the American component with solid lubrication described on page 32, July 6, 1956. The high-tensile ball is located in a nylon cup with a part-spherical seat and the ball completed with a hemisphere of nylon. The forged housing is then swaged down over the perimeter of the domed cap, distorting it into a spring which affords self-adjustment of any clearance that may develop. It is clear that only the heavily loaded part of the ball is metal, and, indeed, reduced weight is one of the advantages claimed by the makers, Chorley Precision Engineering, Ltd. Appropriately enough, the self-locking nut is a " Nyloc."

designed and built to test certain design features which might conceivably be incorporated later on into production models. The car is powered by a modified Pontiac " Strato-Streak " 5·2-litre vee-eight engine with a compression ratio of 10 : 1 developing 300 h.p. The streamlined car has a tubular frame with anodised aluminium panelling, a wheelbase of 8ft 8in, an overall length

The hard top of the Ford " Fairlane " Skyliner coupé retracts into the luggage compartment

of 15ft 6in and a height of only 3ft 2½in from the ground to the top of the windscreen. The independent front suspension has coil springs, while the De-Dion tube at the rear is carried by semi-elliptic leaf springs. The torque from the engine is transmitted via a dry single-plate clutch and an open propeller shaft to the three-speed gearbox and final drive casing, which is rubber mounted at the frame structure. The drive to the 13in diameter road wheels is through universally jointed half shafts.

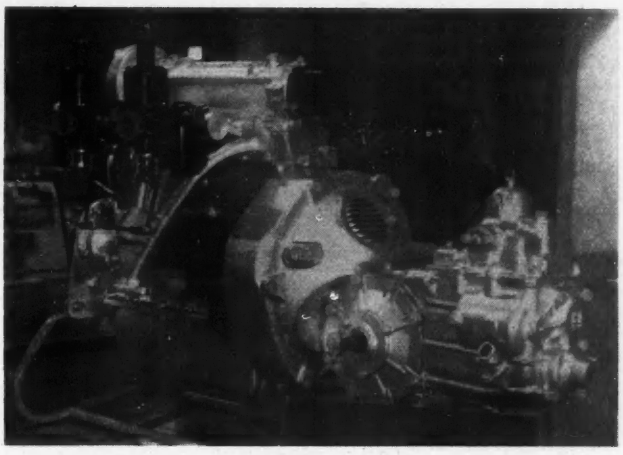
Accessories

We conclude our report of the Motor Show with a short description of some accessories which are incorporated in the construction of the latest British models. This section is of special interest to the automobile engineer as it generally provides at least some examples of experimental design and indicates some trend in which future development might progress.

It is an accepted fact that, with the growing complexity of modern cars, the British as well as the Continental motor industry has to rely on the extensive use of accessories, frequently even of major components, bought from outside suppliers. Since the end of the war many of these suppliers have taken a significant influence on the general principles of automobile engineering. Their work nowadays is confined no more to making accessories according to specifications stated by the car manufacturers, but has been extended to developing on their own initiative a number of useful components which have been successfully incorporated in the design of modern cars. We only mention in this connection the increasing use of rubber in car design, the application of self-energising and disc brakes, servo-assistance to brakes and steering layouts, and, last not least, the various improvements relating to automatic and semi-automatic transmissions. The close co-operation between the automobile manufacturers and the suppliers of components and accessories—many of them having large research and development departments—has proved very fruitful ; indeed, much of the credit given to car designers should actually be shared with the engineers, the chemists and the metallurgists of the suppliers of specialised equipment. The same, of course, applies to the fuel and lubricant technologists of the big petroleum companies who, by intensive research work, provided the necessary requisites for the present development state of the high-performance automobile engine, namely, the high-octane fuel and the heavy-duty lubricating oil. Motivated by the desire to create an additional demand, the suppliers of accessories have generally found novel and original solutions to satisfy the demands upon them and have substantially contributed to progress, even at times when the general conception of automobile design has remained practically static.

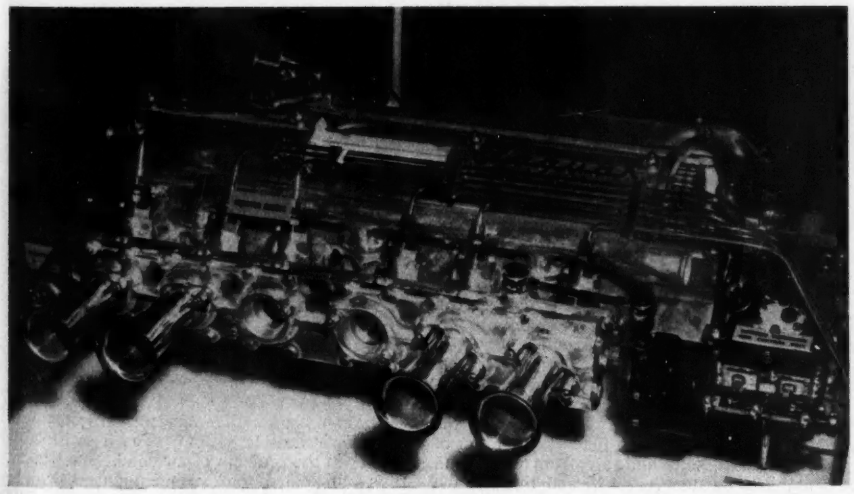
Among the numerous exhibits in the accessory and component section there are two subjects which seemed to be of particular interest to expert visitors—the petrol injection systems and the air suspension.

One of these injection systems, displayed at the stand of Bosch, Ltd., corresponds to the one fitted to the 3-litre, six-cylinder engine of the Mercedes " 300 " saloon, one of the three models shown at the stand of Mercedes-Benz (England), Ltd. The Bosch petrol injection system is based on the design adopted during the last war for aircraft engines, where it has been successfully used to overcome the difficult problem of fuel distribution in air-cooled and supercharged engines. This system has recently been modified by injecting the fuel into the intake ports rather than into the combustion chamber. The Bosch injection pump is similar in design to the multi-cylinder diesel injection pump with built-in metering device, but each pump cylinder has an oil seal which prevents the fuel from penetrating along the pump plunger into the pump drive and from diluting the lubricating oil. The fuel delivery is controlled by the well-known device of a diaphragm, actuated by the variable vacuum of the inlet manifold in response to the position of the throttle. A combined air-pressure and temperature feeler is built into the injection pump in addition to the diaphragm unit; it corrects the mixture ratio according to the ambient temperature and the prevailing air pressure. Spring-loaded injectors are used to spray the fuel into the individual branches of the inlet manifold a short distance before their joint with the cylinder block.



The smallest of the numerous four-cylinder o.h.c. " Climax " engines

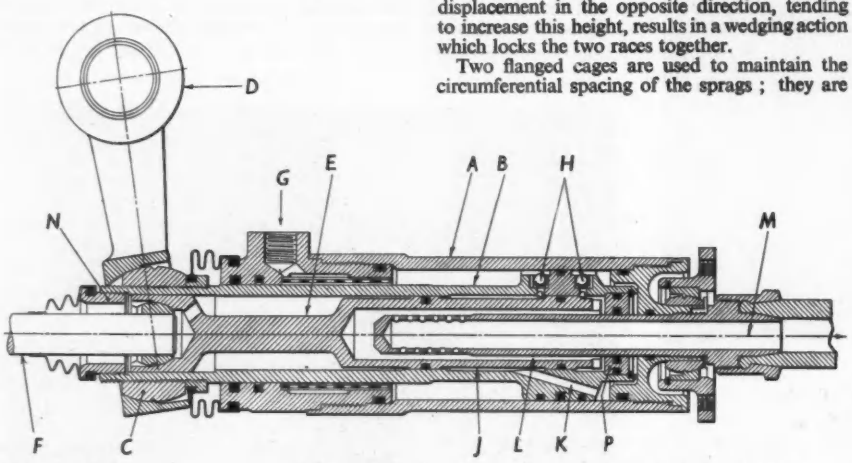
Another injection system which has been successfully employed for the past two years in Jaguar competition cars was demonstrated at the stand of Joseph Lucas, Ltd. It has two features in common with the Bosch system, namely, the injection through spring-loaded nozzles into the intake port of each individual cylinder, and the mixture control in response to the induction pressure in the intake manifold. Instead of the multi-cylinder injection pump, however, it uses one pump only, and a common metering device serving each cylinder in turn. The required hydraulic pressure of about 100 lb per square inch is generated by a gear pump, preferably arranged near to the fuel tank, and driven at constant speed by an electric motor. A relief valve regulates the pressure, surplus fuel being returned to the tank. The fuel is distributed to the cylinders by a tubular steel rotor, which, driven from the engine, rotates in a stationary cast iron sleeve. Radial ports in the rotor, in turn connect with corresponding ports in the sleeve and deliver the fuel through the delivery lines to the individual inlet ducts. The metering device consists of hardened steel shuttles, sliding axially inside the bore of the rotor between a fixed stop and a variable stop, the position of the latter being adjusted by a piston in response to the induction pressure, i.e. to the position of the



A Jaguar 3½-litre cylinder head provided with Lucas fuel injection equipment for display purposes. Notice the throttle plate

throttle. This device is generally sufficient to keep the fuel-to-air ratio constant over the working range ; as a further refinement, other adjustment devices can be incorporated to correct for atmospheric pressure and temperature variations.

Fuel injection systems for petrol engines have a fairly limited application in luxury cars or in fast sports cars. The equipment is expensive, and will hardly be able to compete with the simple and reliable carburetter ; however, should less complex devices be developed, it is quite possible that fuel injection will eventually find a wider application for engines of six or more cylinders. Apart from the advantages normally claimed for petrol injection—more power and lower fuel consumption, better running performance, quicker acceleration and deceleration of the engine and easier starting—its availability will probably lead to lower bonnet lines.



A. Servo cylinder.
B. Differential servo piston.
C. Ball joint.
D. Steering arm.
E. Control piston.
F. Control rod.
G. Oil entry.
H. Ball valves.
J. Annular space.
K. Connecting passage in servo piston.
L. Hollow part of control piston.
M. Oil exhaust.
N. Ring nut.
P. Piston cover.

Combined valve and ram for non-reactive power steering

As pointed out earlier in this report, much attention is nowadays paid to facilitating clutch and gear change operation by means of comparatively simple and inexpensive devices: the efficiency of the systems still depends to some extent on the skill of the driver and heavily on the reliable working of the synchronising mechanism. A great deal of development work has been devoted to overcome existing difficulties, as is shown at the stands of Automotive Products Company, Ltd. (" Manumatic " transmission), Newton and Bennet, Ltd. (Newtondrive), and S. Smith and Sons (England), Ltd. (electromagnetic powder coupling).

The German B.M.W. " Isetta " to be made under licence in this country by Isetta of Great Britain, Ltd., and powered by a fan-cooled 300 c.c. o.h.v. single-cylinder engine, is fitted with a novel two-pedal control system, " Selectroshift," made by Smiths Motor Accessories, Ltd. This system incorporates an improved design of the magnetic coupling, first introduced at last year's show and described in THE ENGINEER of October 26, 1956. As is illustrated on page 628, the electric excitation coil does not form a part of the input member any more, but is contained in a stationary field member attached to the bell housing of the engine. When the coil is energised an electric flux is induced which passes through a narrow air gap to the input member, attached to the flywheel, and then through the magnetic powder, contained in the gap between the input and the output member, back to the stationary magnetic field. This new arrangement greatly reduces the moment of inertia of the input member and makes it possible to effect rapid gear changes with an ordinary " crash-type " gearbox. Dynamo current, which increases as the engine speed rises, is fed to the coil, causing the clutch to engage smoothly ; declutching for gear changes is carried out by interrupting the current to the coil, the electric circuit being broken by the opening of a switch attached to the gear lever knob.

Since the introduction last year of the fully automatic transmission made in this country by Borg-Warner, Ltd., this system has been improved by replacing the roller type freewheel, used for the retention of the stator, by a simple but ingenious one-way clutch. This device, which is illustrated on page 629, serves to transmit torque in one direction only. It consists of a number of hardened steel cams (" sprags "), which are uniformly distributed in the annular space between two concentric races. The contacting surfaces of the sprags are arcs with eccentric centres. Relative angular displacement of the races increases or decreases the angle of each individual sprag relative to the radius of the race and, therefore, its instantaneous height inside the annular space. Relative displacement of the races in one direction decreases the height and results in freewheeling, whereas displacement in the opposite direction, tending to increase this height, results in a wedging action which locks the two races together.

Two flanged cages are used to maintain the circumferential spacing of the sprags ; they are centrally located on the inner and outer races respectively, and the cage windows are so dimensioned that a relative angular displacement between the inner and outer race causes all sprags to engage or disengage the races simultaneously. This action of the cages is supplemented by the light ribbon spring which holds the sprags in position. As all sprags work in unison, each carrying its full share of the load, the clutch is insensitive to shock loads and to torsional vibrations and can transmit high torque with little or no backlash.

A new hydraulic servo-steering unit for cars, based on the Leduc system originally developed for aircraft servo controls, was shown by Turner Manufacturing Company, Ltd. Like other commonly used systems it comprises a hydraulic vane pump (in this case directly coupled with the dynamo shaft), an accumulator with by-pass valve, a servo-cylinder arranged between the steering box and the steered road wheels, and a control mechanism actuated by a linkage to the drop arm of the steering box.

The servo-cylinder *A*, attached on its right-hand side to the frame structure, contains the differential servo-piston *B*, which, on the left-hand side, is connected by the ball joint *C* to the track rod or to the steering arm *D* of one road wheel. Slidably mounted inside the hollow servo-piston is the control piston *E*, which is flexibly jointed through the control rod *F* with the drop arm (not shown in our illustration) of the steering box. The effective area of the servo-piston is twice as large on the right side as on the left side ; in the balanced state the oil pressures on either side of the cylinder are inversely proportional to the corresponding piston areas. Oil is admitted from the accumulator through the port *G*, and as long as the pressure in the two partitions of the cylinder is balanced, the valves *H* remain closed. If the control rod with the control piston is moved to the left, the ramp of the latter lifts the left-hand valve from its seat, and oil at high pressure is transferred through the annular space *J* and through the bore *K* to the right, low-pressure, side of the cylinder. Control piston and servo-piston move in the same direction until the balance of pressure has been restored. Moving the control piston in the opposite direction causes the other valve to open, in which case oil is released from the right side of the cylinder and, through the hollow part *L* of the distributor piston and the exhaust pipe *M*, is returned to the oil reservoir. Should the hydraulic pressure fail, the control piston is positively linked to the servo-piston by two abutments, provided on the left by the ring-nut *N* and on the right by the piston end cover *P*.

An improved bearing material, said to be particularly suitable for heavily loaded mains and big ends of engines, has been developed, in conjunction with the Tin Research Institute, by the Glacier Metal Company, Ltd. The exhibits comprise thin-wall, steel-backed high-tin aluminium alloy bearings of a metallurgical structure which combines a comparatively soft bearing surface with higher fatigue strength than that of any other bearing alloy yet produced. Several examples of these reticular-tin aluminium bearings were shown at the stand, including some returned for inspection after arduous testing in one of the 35,000 vehicles already using them in regular service.

Another interesting exhibit at the Glacier stand was a 2in diameter white metal bearing that has run for some considerable time at 1500 r.p.m. with a load of 6000 lb per square inch. This result has been obtained by attention to details of manufacture, design and fitting, and has established criteria which can be translated into everyday design ; it may well increase the safe loading for white metal by 50 per cent or more in many applications.

Another new bearing material is the " DP 3," a steel-backed porous bronze material impregnated with the now well-known low friction plastic P.T.F.E. (polytetrafluoroethylene). It can be used with advantage in cases where oil dripping on to fabrics is to be avoided, and has found its place in a friction clutch and, further, in brake pedal bushes in at least one British leading car.

On the stand of Coventry Climax Engines, Ltd., in the Motor Boat Section, were shown several of the four-cylinder, overhead camshaft engines which are currently being used in sports and racing cars. An engine of this make distinguished itself by winning the Index of Performance in this year's twenty-four-hour race at Le Mans, an honour that has seldom been wrested from the proficient builders of small cars on the Continent of Europe. Even smaller than the victorious Lotus engine was that illustrated, which is expected to be applied initially to marine propulsion. While it is basically similar to the other single-camshaft engines, it is notably more refined ; the illustration shows the drive to the distributor direct from the camshaft, and the use of mechanical, not electrical, positive engagement of the starter pinion.

The first air conditioning equipment for motor-cars made in this country is shown by Smiths Motor Accessories, Ltd. It employs the vapour compression system : a highly volatile refrigerant under high pressure is passed as liquid through a throttle valve into the evaporator. Air passing through the evaporator will give up some of its heat to the refrigerant, thus changing its state to a gas before passing to the suction side of the compressor. Here the pressure of the gas is raised so that it is capable of being easily condensed at a relatively high air temperature in a second heat exchanger, the condenser. Here heat is given up, the refrigerant becomes liquid again, and the cycle is repeated.

The Smith air conditioning set, depicted on page 629, shows the belt-driven compressor, the evaporator mounted under the bonnet, and the condenser suitably arranged in front of the main cooling radiator. The evaporator is preferably combined with the heater system in order to use, where possible, common air ducting and blowers. The complete evaporator and heater unit is less than twice the size of a heater alone.

The combination of a refrigeration system with a fresh air heating system offers a satisfactory answer to the problem of air conditioning a car. It is anticipated that such equipment will be offered as an optional extra on the majority of medium-sized and some small British cars in the fairly near future.

Developments in Underground Gasification

In abstracts from a Ministry of Fuel and Power report on underground gasification trials in this country, published in our issue of April 20, 1956, we gave some particulars of the early trials with the "blind bore-hole" technique at Newman Spinney. A paper on recent developments in underground gasification, presented to the North of England Institute of Mining and Mechanical Engineers on October 5 last by Mr. C. A. Masterman, states that this technique is showing substantial advantages over previous methods tried here and overseas. The following abstracts from Mr. Masterman's paper show the progress made with the technique since the original report and examine the future possibilities.*

UP to the time the blind bore-hole technique was described in the 1956 report, little progress had been made owing to high temperature failure of the air supply pipes. Trial No. 49, ignited in October, 1955, and gasifying for over six months, confirmed the prospect by this technique of a great advance in the process. Since then all available effort has been focused on its development.

TABLE I—*Blind Bore-hole Trials*, 1956/57

Trial No.	Average depth, feet	Initial length, feet	Ignition date	Period alight	Coal tons gasified
49	60	160	October, 1955	6½ months	400
50	80	450	March, 1956	3 days	1
51	80	300	April, 1956	7 days	5
52	80	150	June, 1956	35 days	40
53*(*a*)	5	300	August, 1956	hours	—
(*b*)	5	300	April, 1957	3 days	5
(*c*)	5	300	April, 1957	6 days	10
(*d*)	5	300	August, 1957	4 days	8
54	95	350	October, 1956	4½ months	480
55	130	190	July, 1957	Gasifying	100+
56	120	250	Pending	—	—

* The series of tests comprising trial No. 53 was conducted in an artificial "bore-hole" near the surface to compare various air tube materials.

NOTE.—Other than Nos. 55, 56 (both in the Sough seam) and 53, all the trials were in the Fox Earth seam, which is so interbanded with dirt that the 3ft of coal extends over 9ft of total thickness and the seam is not economically mineable.

In the new "blind bore-hole" technique, the air is not merely blown through the bore-hole or channel to pass out as gas at the other end. Instead, the bore-hole is drilled to a blind end having no outside connection. An air supply tube of smaller diameter is inserted nearly the full length and through it air is passed to supply a gasification reaction at the far end. Possible dimensions are: length 300ft, bore-hole 12in diameter, air tube 4in internal diameter. The gas passes back from the reaction to the mouth of the bore-hole in the gallery through the space between the tube and the bore-hole wall (see Fig. 1). The gas leaves the reaction at high temperature and, in passing over the air supply tube, transfers heat to the incoming air, which reaches the reaction at 700 deg. Cent. or more.

Several advantages stem from this. The reaction does not move downstream as long as contact with ungasified coal or coke is maintained. Downstream movement is therefore slow, leaving behind a gasified zone of full width (Fig. 1). This was confirmed after trial No. 54 by drilling and coring in and round the gasified zone, which was found to be of a fairly consistent 9 yards width (3ft coal thickness). On the gallery side of the reaction the bore-hole appeared to have been left virtually ungasified. A bore-hole 300ft long, operating at an air flow of 25,000 cubic feet per hour, should therefore produce usable gas (25 therms per hour) for about seven months in continuous operation. In trials Nos. 49 and 54 this proved in principle to be the case, the gas averaging over 80 B.Th.U. per cubic foot.

Trial No. 54 was closed down at about half-life after nearly five months' operation (when some 480 tons of coal had been gasified), owing to the stripping of a thread on one of the air tube connectors at the cool end, possibly due to thermal movement of the pipe as a whole. Had it not been for this fortuitous failure, the indications are that some 900 tons of coal would have been usefully gasified on this single bore-hole. No reversals of air flow were involved.

Ideally, the air supply tube should burn back as the coal is exhausted and the reaction gradually moves back towards the gallery. The pressure loss up the tube and back through the bore-hole would then fall, with saving in pumping costs. But it is more important that the air tube should not fail prematurely owing to high temperature or other cause. It is the period immediately following ignition which appears most critical. The surface area of the gasifying zone, subject to heat loss to the strata, is then at a minimum, while heat transfer (about 5 therms per hour) to the air tube of full length is at a maximum.

The transfer of heat from the outgoing gas to preheat the incoming air reduces the gas temperature and its heat loss to the bore-hole walls. The system loss as sensible heat in the exit gas is reduced. The result is a change in the thermal balance towards higher efficiency as C.V. (calorific value) and hence towards a higher useful thermal yield. The average thermal analysis of eight observations in the course of trial No. 54 at 25,000 cubic feet per hour air flow was as follows:

Total heat from coal	38·3 therms per hour
Heat as C.V. in gas	25·4 therms per hour
Sensible heat in exit gas	4·7 therms per hour
Heat as water vapour	2·9 therms per hour
Heat to strata (by difference)	5·3 therms per hour
Cold efficiency as C.V.	67 per cent

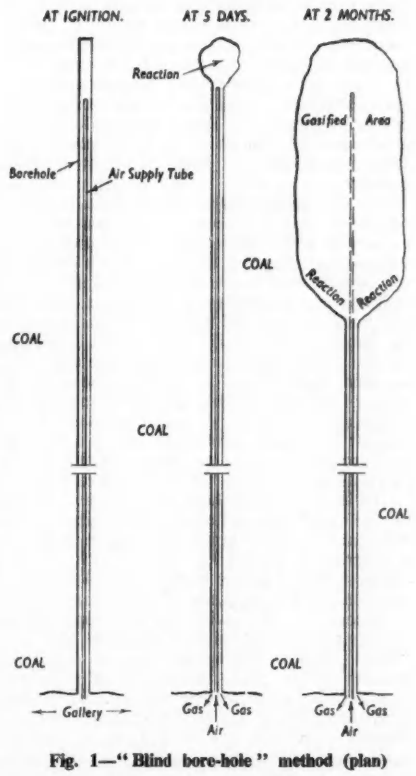


Fig. 1—"Blind bore-hole" method (plan)

The blind bore-hole technique would be applied in practice by the drilling of a number of bore-holes in the coal on both sides of a gallery. Similar sets of bore-holes would be drilled from other parallel galleries. Hence, between galleries there would be two sets of bore-holes with a dividing barrier between their ends (Fig. 2).

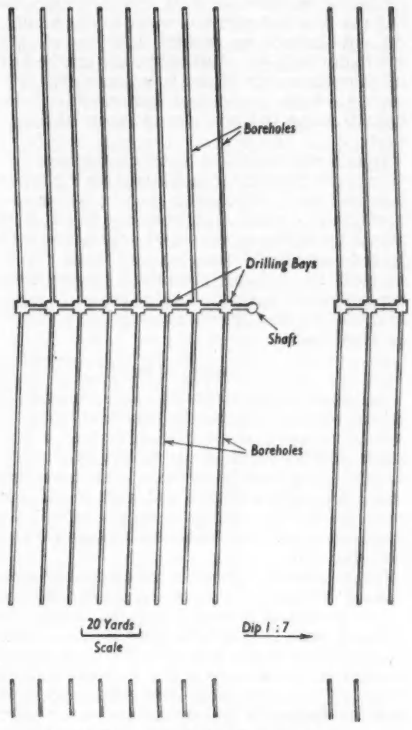


Fig. 2—Part of pilot system (plan)

Trial No. 55 on a single bore-hole with chrome iron (and part length refractory) air tube was ignited early in July, 1957. Trial No. 56, the first of four multiple blind bore-holes, is due to be ignited in September, 1957. Other trials are due in the No. 53 series. Tests continue with directional drilling. Preparations are being made for the pilot system.

Experimental Details

The earliest bore-hole trials were mostly prepared by drilling into a coal face exposed at the surface. This is unsatisfactory in that the coal tends to be weathered and, in the inevitable drilling down dip, water is liable to be locked up at the far end of the bore-hole, rendering ignition difficult.

The current trials involve the provision of a shaft (say, 6ft 6in diameter) and heading, even for a single bore-hole test. The bore-hole is then drilled at an angle to enter the seam slightly uphill from the heading. These preparations, together with extensive instrumentation, may involve the expenditure of over £20,000 before the trial starts, and any trial being an experimental venture, may have only a short life.

On completion of drilling and survey, the air supply tube is inserted. Mild steel has been used but current trials involve high-chromium-content iron sleeved at the forward end with refractory tubes to give sufficient protection against excessive temperature and corrosion. Thermocouples in the air and gas ways are associated with the air tube. A small tube is also inserted full length, carrying at the forward end an electrically ignited firework (in waterproof container), whereby propane or other gas fed up this tube can be ignited to start the coal reaction.

At the gallery end the air tube connects to a heat exchanger sealed into the coal face through which the incoming air is circulated as a temperature buffer between the hot outgoing gas and the adjacent coal. Both air and gas are connected by pipeline through the gallery and up the shaft to the surface. In a multi-bore-hole system heat exchangers would not be used and the gas would be vented direct into the gallery and up the shaft.

Instruments on the surface include recorders for temperature, calorific value, gas constituents

* Formerly Technical Director, Underground Gasification, Ministry of Fuel and Power, now on the staff of Humphries and Glasgow, Ltd.

(including moisture content), specific gravity, air and gas flow and pressure, water levels in sump, &c., supported by manual analysis of gas, ventilation air, &c. Part of the gas can be bled off to operate a gas engine to generate electricity (purely for the purpose of demonstration), the balance being burned on a stack or blown to waste.

It must not be implied that such extensive provisions are required for each bore-hole in a multi-bore-hole trial, still less for each bore-hole in a commercial system. The present object is to obtain the fullest experimental information on a process necessarily invisible and liable to be affected by natural conditions underground beyond human control. The object of all this is to render the final process as cheap and as simple as possible.

Development Aspects

Although the practicability and advantages of underground gasification by this blind bore-hole technique are now established beyond doubt, much remains to be done by further trials to determine optimum conditions and lowest gas cost. It is to be supposed that trials to that end will continue for some years in parallel with the operation of the pilot from which much will also be learnt.

(*a*) *Preparatory Costs.*—A substantial proportion of the ultimate cost of the gas will depend upon the cost of sinking the shafts, driving the galleries and drilling the bore-holes. Directional drilling in particular is in its early stages. On full commercial scale for a single station, some 10 miles of bore-hole with associated galleries and shafts will be required every year. This preparatory work will be largely repetition work to standard dimensions, different from conventional mining, and considerable streamlining of techniques should be possible to reduce costs.

(*b*) *Air Supply Tube.*—This tube is exposed to very searching conditions. Temperature at the reaction end is liable to be very high, the inside is exposed to oxidising conditions, the outside to reducing conditions (dirty gas containing sulphur), and mechanical stresses are imposed by thermal expansion and contraction. Mild steel has sometimes failed and chrome iron with heavy screw threads, protected outside with refractory sleeves, is now being used. This is expensive and a cheaper alternative is desirable though not vital. A continuous refractory pipe cast *in situ* may be a possible answer.

Water injection has been used on occasion to control excessive temperature rise but is unattractive as a long-term method. An alternative being tried is to bleed off a predetermined proportion of the gas from the reaction through a supplementary bore-hole drilled slightly obliquely from the face to intersect at the far end. If the value of this "heat leak" method is confirmed, the supplementary bore-holes would take over part of the gasification and the main bore-holes might be spaced further apart with overall saving in cost.

In the last resort shorter bore-holes will reduce preheat and lower the temperature of the pipe.

(*c*) "*Runaway Bore-holes.*"—Multiple bore-hole trials have not yet been operated by this blind bore-hole method. The first one is now in preparation and may reveal new features, favourable or adverse. In broad principle all the air pipes will be supplied from one manifold and all the gas will be vented into the gallery and up the shaft. Misbehaviour of one or more bore-holes might be prejudicial to the quality or output of the gas. There are two conditions to be considered.

If one or more bore-holes fail to ignite, air will pass back to the gallery to mix with the gas. Provided there is not sufficient to cause explosion, this is of minor importance and only increases pumping charges per therm of gas. It might reasonably be assumed that as the reactions in the adjacent bore-holes develop, they will ultimately ignite the laggard bore-hole(s).

Reference has been made earlier to the failure of reactions to keep in step when operating in normal bore-holes with repeated reversals of flow. This difficulty should be less with blind bore-holes operated without reversals. At the worst, one or more reactions will reach the gallery ahead of the others, dictating a close-down before all the available coal has been gasified. Only experience will show whether this loss of potential gas is economically serious. One precautionary measure would be to ensure that the air supply is equally distributed to all bore-holes and a governor is being developed for that purpose. An alternative or addition is to install a closure device, on the gas exit from each bore-hole, operated, for instance, by rise in temperature of the coal as the reaction approaches the gallery. Such a device is being developed in case it is required.

(*d*) *Calorific Value.*—Fluctuations occur in the gas quality, though the new technique has overcome the deterioration-with-time characteristic of other methods. The reason for these fluctuations is not yet understood, though in some cases they can be attributed to falls of coal or roof in the gasifying area. Provided they are fortuitous in affecting different bore-holes at different times, they will average out in a multi-bore-hole system. It remains highly desirable to confirm this and discover whether other causes, which can be controlled, also operate.

(*e*) *Dimensions and Air Rate.*—The present plan is to use bore-holes about 100 yards long, 12in diameter, with 4in internal diameter air pipe. These will operate initially at 10 lb per square inch, with an air flow each of 25,000 cubic feet. As the reaction proceeds, the pressure loss falls. The cost of the gas should be reduced by using longer bore-holes, other things being equal. But longer bore-holes would require larger diameters if higher pressure loss is to be avoided. This may or may not prove economic. Further, the temperature of air preheat might rise unduly. There is nothing sacrosanct about the proposed air flow of 25,000 cubic feet per hour and the optimum may be related to the wetness and thickness of the seam.

Other dimensions will come under review before planning full-scale systems. It will need to be decided what spacing is best between bore-holes, how many bore-holes are best served by a single shaft and, hence, the length of gallery required, and what safety barrier must be left between independent sections (each based on a shaft and gallery) to ensure that no leakage of gas takes place from a section in operation into one being prepared. This last condition will be greatly eased by the intention to exhaust the gas from the gasifying system at slight negative pressure.

(*f*) *Fluctuating Output.*—The primary aim in the recent trials has been to reach and maintain a desirable level of gas output. Some preliminary information gained in trial No. 49, on the result of attempting to vary the level of output at will, indicates the possibility of difficulties. On the one hand, undesirable temperature changes may be imposed on the air pipe in the bore-hole. On the other hand, changes in air rate are likely, at least temporarily, to change the calorific value of the gas. In the extreme if the air is cut off altogether, high C.V. gas, of a total thermal content not much below that of the low-grade gas produced with air, may continue to be evolved for some time. More work is required.

The importance of this feature lies in the need for the C.E.A. to meet a fluctuating demand, the national load factor being about 45 per cent. If underground gasification proved to be the cheapest technique for meeting base load, as is possible, it would no doubt be a welcome addition to resources. But with the development of nuclear power at its high capital cost (and low "fuel" cost) as the agency for base load, the meeting of the peak demand by other means may become an increasing anxiety. If, as has been forecast ("A Programme of Nuclear Power," Cmd. 9389. H.M.S.O., 1955), nuclear power may be providing some 40 per cent of our electricity by 1975, and if the overall load factor remained as now, the 60 per cent balance of demand would represent under 30 per cent load factor. A flexible low cost output from underground gasification might then be a specially useful complementary source of supply.

(*g*) *Different Types of Coal.*—The only coals in which trials have been carried out in U.K. are the mildly coking coal at Newman Spinney and the non-coking faulted coal at Bayton (now closed down). Other coals and formations, including steeply sloping seams, require to be tested to find out what modifications, if any, are required to obtain the best results. Some coals or seams may prove quite unsuitable. In other and perhaps especially in drier seams, better results than those achieved hitherto may be obtained. A method for gasifying multiple seams in the same site requires to be developed.

(*h*) *Utilisation of the Gas.*—The obvious use for gas produced by air, of calorific value under 100 B.Th.U. per cubic foot, is to generate electricity on site. Three possible prime movers have been considered: boiler plant, gas engines and gas turbines. Both the latter may involve additional gas cleaning at substantial expense to eliminate the contained dust and tarry matter, but this is not necessarily final. For demonstration purposes a high compression (14 : 1) gas engine has been used on site on gas down to 70 B.Th.U. per cubic foot to generate electricity. The present intention is to use boiler plant with a turbo-generator. As compared with modern power stations the thermal efficiency is likely to be less at, say, 25 per cent, but capital charges are reduced in the absence of coal and ash-handling equipment.

The gas quality is exceptionally low for commercial use and further work is required on combustibility in relation to the design of burners and combustion chamber. In particular, the moisture content of the gas is a diluent in regard to calorific value and partial dehydration may be necessary.

Oxygen has only been used in U.K. trials as an aid to high-pressure linkage. Its use with or without steam as a gasifying agent has long been familiar in theory as a method whereby the calorific value of the gas would be raised. In Russia before the war, with air enriched to 70 per cent oxygen, an underground gas of the following composition was obtained :—

CO_2	O_2	CO	H_2	CH_4	N_2	C.V.
20	0·2	28	30	10	11·8	286

Such a gas could be transmitted by pipeline for blending and use as town gas or it could be used for synthesis processes. Comparatively small expenditure on trials would greatly aid the assessment of the economic potential.

Pilot System

In addition to further development work, preparations are in hand for a pilot system able to produce sufficient gas to generate 5MW continuously for several years. This is about one-tenth the size of a minimum commercial system. Operation is scheduled to begin next year. The purpose is twofold: on the one hand, to demonstrate the process and probable costs, and, on the other, to provide technical information to aid in the design of full-scale systems.

The pilot is to be prepared on an area adjacent to the original site at Newman Spinney. It will consist of a number of sections or arrays, each served by an 8ft diameter shaft giving access to a gallery 100 yards long with ten bore-holes 100 yards long, drilled on each side from bays at 10 yards spacing. Owing to the dip of 1 : 7 the depth below surface will change from about 150ft to over 300ft. Later ones may differ from this in design and in dimensions as a result of experience. The early sections aim to gasify nearly 20,000 tons of coal apiece. Two sections operated simultaneously will provide the desired gas output, about 1,000,000 cubic feet per hour, life in continuous operation being over six months. New sections will be brought into operation as old ones become exhausted. The air will be carried by pipeline (up to 36in diameter) from the blowers at a maximum of 10 lb per square inch to the tops of the shafts and thence by ducting and manifold to the air tubes in the bore-holes. The galleries with the shafts carry the gas from the bore-holes to the surface. The gas will be water cooled, in the galleries and shafts, to leave at the appropriate dewpoint to maintain combustion at the burners in the boiler. A booster will be inserted on the main gas pipeline (48in diameter) between the shafts and the power station to maintain a negative pressure in the galleries. Gas and air may be preheated with chimney heat at the power station.

A gas-fired boiler is to be used, this and a turbo-generator transferred from service elsewhere being provided and installed by the Central Electricity Authority.

Design and Estimated Costs (Full Scale)

Throughout the period of the trials since 1950, it has been essential to keep probable commercial

costs under observation as a safeguard against continuing to spend money on a project having no economic future.

In the context of electricity generation the criterion was the cost of coal delivered to power stations, including handling. This has risen from 54s. per ton or about 2¼d. per therm average in 1949–50, to nearly £4 or about 4d. at the present time. For individual power stations it may differ by up to 20 per cent above or below the average. But the long-term result of using underground gasification is to relieve the pressure on coal and oil supplies and to reduce the level of fuel importation costing over 6d. per therm, which perhaps is a truer criterion.

In order to estimate full-scale costs certain assumptions must be made as regards design, performance and engineering. On the basis of trials, and further to be confirmed in the pilot, the design is assumed to be based on the blind bore-hole technique.

To maintain a continuous output of 60MW, about 400,000 tons of coal must be gasified annually (a conventional station with this output would spend about £1,000,000 annually on fuel). A load factor of, say, 50 per cent, seems commercially more likely than 100 per cent. Further, only a proportion, say, 85 per cent, of the coal in the seam (240 therms per ton of coal) will be gasified. The coal required in the seam for one year's operation would then be about 250,000 tons, or, say, 2½ square miles of 3ft seam for a thirty years' life. A smaller acreage would be required if several seams were gasified on a single site, or if the seam were thicker.

The cost of gas production depends upon design features which cannot yet be finalised and upon engineering costs which are likely to fall as experience is gained. Estimates prepared now (Table II) can therefore be no more than examples

TABLE II—*Cost Estimates*

Assumptions (subject to later revision)	Experimental (1959)	Commercial (1962)
(*a*) Item costs :		
Shafts per foot	£60	£40
Gallery, per foot	£20	£15
Bore-hole, per foot	5s.	2s. 6d.
Air tube, per foot	30s.	15s.
Electricity, per unit	¼d.	¼d.
(*b*) Design dimensions (per shaft) :		
Coal tonnage (3ft seam) ...	100,000	200,000
Gallery length, feet	1,500	2,500
Number of bore-holes... ...	100	170
Bore-hole length, feet	300	360
Air, cubic feet per hour ..	2,500,000	4,250,000
Shafts in operation	4	2
(*c*) Performance (total output):		
Gas, cubic feet per hour (S.T.P.)	11,500,000	10,250,000
Calorific value (B.Th.U. per cubic foot)	75	85
Gas per ton of coal gasified, therms	150	180
Total gas produced, therms	60,000,000	72,000,000
Pressure loss (average), pounds per square inch	10	7½
Life at 50 per cent load factor	20 months	24 months
Calculated costs(approximate):		
Total :		
To gasify 400,000 tons ...	£1,000,000	£500,000
Per therm of gas	4d.	1¼d.
Per ton coal equivalent ...	£4	35s.

NOTE : No allowance is made for cost increases in steel, coal or labour, 1957–62.

pending firm evidence from the pilot. A similar difficulty confronted those responsible for the present nuclear power programme, in comparison with which the probable costs of underground gasification can be estimated with more assurance.

The first example relates to a full-scale system as it might be designed now experimentally to ensure maximum reliability at present engineering costs, the system to begin operation, say, in 1959.

The second relates to a system as it might be designed commercially, say, three years hence, when possible improvements in technique have been confirmed and the engineering work has been streamlined, operation to start in about 1962.

The former is, in effect, the present design and expected performance of the pilot, but is increased in scale to become more nearly economic. The second example anticipates that many improvements will arise in the next three years and that in particular sufficient confidence will have been gained to increase greatly the coal tonnage gasified per shaft. In the experimental design some twenty-six shafts are used per square mile, compared with thirteen in the "commercial" design (depth about 400ft). In the former, four shafts will be in simultaneous operation ; in the latter only two. Costs are based on the supposition of a total life of twenty to thirty years, new sections (shafts) being brought into operation as old ones are exhausted. Hence some of the equipment (e.g. air blowers) will be in use for many years and only a share of the cost will be borne by the gas from a single shaft.

The approximate cost estimates are made on the basis of gasifying 400,000 tons of coal, a fraction of the total, to generate 60MW (8500 therms of gas per hour). These estimates can do no more than indicate the probable level of costs as now visualised. A thicker seam would substantially lower costs, a greater depth would slightly raise them. Design dimensions are significant. For instance, if the bore-hole length could be increased, say, to 500ft, without ill-effect, the gas cost (commercial) would fall to about 1½d. per therm. The calculated cost for electricity generated by gas at 1¾d. per therm, after making adjustments for reduced efficiency and lower capital cost, is about 0·4d. per unit for base load. Even at under 50 per cent load factor it still remains cheaper than 0·6d., which is the published estimate for cost at base load from nuclear stations.

The foregoing relate to the production, using air, of low-grade gas for the generation of electricity. More speculative is the cost of higher grade gas using oxygen, since no trials have been carried out in U.K. on the kind of system which would then be considered suitable. Owing to the reactivity of oxygen with coal, reversals of the direction of flow on a simple bore-hole system would probably not be necessary and operation might be more straightforward than with air.

Tonnage oxygen could be produced from a plant on or near the site (electricity 1d. per unit) at less than £2 10s. per ton (1s. 10d. per 1000 cubic feet). If 4000 cubic feet of 300 C.V. gas were produced per 1000 cubic feet of oxygen, as seems probable from Russian pre-war trials, the oxygen cost would not exceed 2d. per therm. Total gas cost seems likely to be 3d. to 4d. per therm. As such it should grade for consideration for blending with town gas produced and purified at about 1s. per therm. It is likely to contain over 20 per cent CO_2, which, for synthesis under pressure, could be easily removed, thus raising the C.V. to nearly 400 B.Th.U. per cubic foot.

Unusual Corrosion Problem*

ENGINEERS are well aware that corrosion may be due to many causes. A recent case was unusual in that bacteria were shown to have been responsible for attack upon copper alloys in a heating system, and a description of the problem and its solution may be of interest. The heating system concerned is of the high-pressure, hot-water type, and includes four boilers each with a heating capacity of 46,000,000 B.Th.U. per hour. The volume of water in circulation is between 30,000 and 35,000 gallons, and flow and return temperatures of 350 deg. and 250 deg. Fah. respectively are maintained. Pipework is of steel, but there are a large number of copper alloy heating units, each separately controlled by motorised three-way valves. It was the repeated sticking of these valves which first drew attention to the problem. To allow for expansion and contraction in the system due to temperature changes, an overhead surge tank is fitted. A pressure vessel fitted in a leg of the main circulating system measures changes in volume of the circulating water and initiates valving and pumping cycles to transfer water to and from the overhead surge tank as required. The pressure vessel has an upper atmosphere of nitrogen, used in preference to compressed air to avoid pick-up of oxygen by the circulating water. Chemical treatment to prevent corrosion and scale formation in the circulating system consists of regular addition of alkali, phosphate, coagulant and sodium sulphite to maintain zero hardness, an alkaline pH and freedom from dissolved oxygen.

Detailed examination of copper heating elements and control valves showed the presence of a thin film of black deposit. This coating, although not enough to affect the heating units, was sufficient to inhibit the action of the motorised valves and cause them to stick. Examination of the deposit showed it to consist of cuprous sulphide. There was no oxide deposit present, and the steelwork generally throughout the system was not attacked. There seemed to be no obvious chemical explanation for the formation of cuprous sulphide, and the possibility of bacterial action was therefore considered.

It was known that the bacterium desulphovibrio desulphuricans can reduce sulphates and sulphites to sulphides under anaerobic conditions (i.e. in the absence of oxygen), but although this bacterium has a marked tolerance of increase in temperature, it cannot live at the very high temperatures obtaining in the circulating portion of a high-pressure, hot-water system. It seemed unlikely that bacteria could be the cause of the trouble until it was realised that the working temperature of the semi-stagnant water in the pressure vessel would be much less than the main system. The pressure vessel was therefore opened for examination and proved to contain a considerable amount of black organic sludge. At this stage the very ready co-operation of the microbiology group of the Chemical Research Laboratory (of the Department of Scientific and Industrial Research) was sought. They showed that the organic sludge contained desulphovibrio desulphuricans in large numbers. Their knowledge of the habits of such bacteria confirmed the belief that the bacteria, by acting upon the sodium sulphite in the circulating water could produce hydrogen sulphide, which, passing into the main system, caused attack upon copper-containing materials, and this was the root cause of the operating troubles experienced.

Once the cause was known the solution to the problem was simple—to control the growth of the bacteria. The pressure vessel and the surge tank (which had also shown signs of bacterial activity, but in much less amount) were thoroughly cleaned and sterilised with a solution of sodium hypochlorite. Thereafter they were resterilised at regular intervals by the injection of hot water from the main system to achieve temperatures of about 220 deg. Fah. This was achieved by installing lines from the blow-down header of one of the boilers to the pressure vessel and surge tank. As a result of this simple procedure the system has operated entirely free from trouble for some time.

Although the final solution proved so simple, the evaluation and assessment of the problem had, in fact, necessitated a long and detailed investigation, during which the services of chemists, metallurgists, corrosion experts and biologists had been called upon—an unusually wide range of interests which demonstrates the complexity of the science of treating water.

* Communication from Imperial Chemical Industries, Ltd.

Developments in Ultrasonic Machining

SOME further information has now been released by Kerry's (Ultrasonics), Ltd., Tonbridge Road, Harold Hill, Romford, Essex, on its method of threading tungsten carbide, glass, ceramics, &c. Lengthy efforts to thread such materials by feeding the revolving workpiece on to the excited tap, it is stated, failed completely when the tap was mounted in the conventional manner, axis vertical, on its supporting stub. However, when the axis of the tap was turned through 90 deg., and the workpiece was fed horizontally on to it, success was achieved. It is claimed that the vibration of the active end of the tap includes a component of rotation about its axis, and that this angular motion materially assists the process. Feeding is manual and the necessary "feel" is said to be easily acquired.

Another development announced by the company, and one that has also been empirically arrived at, is the interposition of a relatively large and massive steel "box" between the stub and the tool in ultrasonic drilling machines. The top and bottom of the box are flat and a hole of uniformly oval section passes horizontally through the middle of the otherwise solid body. It is claimed that the displacement of the tool, which is mounted centrally on the underside of the box, vertically in line with the stub, is much amplified if suitable dimensions are chosen and substantial increase in the rate of drilling is obtained.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

TECHNOLOGY AND WISDOM

SIR,—In to-day's high economic seas, technological education is seen as a lifeboat and the similarity is likened in that there are more anxious to get into it than show enthusiasm for leaving it. Your editorial of August 30 would seem to be typical of this one-way traffic for whilst you apparently advocate the technologist learning Latin and Greek, you do not say what is to be removed from an already bulging syllabus, to make this possible. Apart from the many vested interests striving to educate us as antiquarians rather than engineers let it be admitted that there is general agreement with your expressed feeling that something has gone wrong with our standard of values. In view of the urgent need for a remedy, it is important that we do not take our medicine from the wrong bottle, as we are in grave danger of so doing when we look nostalgically backward before stepping forward.

Dean Inge observed that "it tells us nothing of Newton to know that he once had a tail," and we should be more concerned with the present and the future than the past, since the theory of evolution applies to human problems as well as human beings. The fact is that we live in an age of spiritual decadence and corruption and it is all too easy to see nothing good in the present time. Teaching Latin and Greek to technologists is no answer to anything, culture is far better measured by the sale of many thousands of Penguin translations of the Odyssey than it is by the sale of a few hundred cloth-covered, gilt-titled volumes in Greek. As Inge has pointed out, it is futile to identify classical education with linguistic proficiency ; indeed, because of a number of well-annotated translations one suspects that a "classical" education now trains only the memory—"the most worthless of our mental powers."

What is needed is a return to religion, to decent standards and a non-economic sense of values, and it would be more valuable to teach the technologist, philosophy, economic history and how to manage people, rather than forge his mind to a pattern which has failed so dismally in the past, and is obviously futile in the present.

If we look back at the early part of the eighteenth century, at the prelude to industrialism, when technological education did not exist, but classical education did, we find some interesting facts recorded. Out of a total population of 5,500,000 persons there was an "unprofitable" majority of 2,795,000 persons dependent in varying degrees on the "charity" of the nation and poverty was the lot of many others not in this majority. Does anyone really believe there was more culture then than now, that there was greater wisdom in dealing with the nation's affairs, or that there was more enterprise and ambition ?

Can we, sir, hope for more realism in your views on this subject and for more of that "sense of curiosity"—that imagination—you called for in your editorial.

Lastly, may I acknowledge D. A. Ogilvie's letter in your issue of September 6 and note that he believes that to really enjoy being hungry one should be thirsty as well !

CHARLES SIGSWORTH

Walsall,
September 24, 1957.

[Where did our correspondent get the impression that we advocated including Latin and Greek in a technological education ? The object of the leader was to point out that an "educated" man is not necessarily a "wise" one, and to suggest that education should not be too narrowly technical as wisdom comes from breadth of understanding. Mr. Sigsworth has been misled by a quotation, printed in the leader, from Jefferson. In his day the broadening of a scientific education would necessarily have meant the inclusion of the study of Greek and Latin. Mr. Sigsworth, we think, should read the leader again. He will find much in it that supports the opinions expressed in his letter. —ED., THE E.]

PURIFYING BRACKISH WATER BY ELECTRO-DIALYSIS

SIR,—As you can imagine, we were very much interested to see the articles on electro-dialysis which you carried in your September 6 and September 13 issues. Ionics developments in the electric membrane field have been reported elsewhere, but your article was the first comprehensive report in a British publication as far as we know. The second article on the plant designed by William Boby and Co., Ltd., for Tobruk was also of interest because little information has so far appeared on this plant.

With respect to the articles, we believe two comments are pertinent. An Ionics plant cannot properly be described as "a prototype plant" in the sense that the plant designed by William Boby is a prototype. Our most recent compilation, as of July 1, 1957, shows some 80,000 hours of operating time on sixteen units, with a number of other units slated for installation in the immediate future. The William Boby plant sounds more like a true prototype since it has been tested in the laboratory but not apparently in the field and there can, accordingly, be no firm knowledge as to its performance and costs under field conditions and over a period of years.

The reading of your article of September 13 also brings to mind the following questions, which, I believe, would clarify some of the points in the article. We would be grateful if you could answer them or obtain answers for us. How large are the membranes used in the Torbruk plant ? There is some confusion in our minds on some of the figures mentioned in the article as to whether they apply to a 50-membrane or a 200-membrane plant. For instance, mention is made of maximum potential difference of 217V. To how many membranes does this voltage apply ? Is any data available on the circulation rate of the diluate in the 50-membrane plant ? In the article it is stated that it is "re-circulated between five and ten times in an hour."

WILLIAM E. KATZ
Treasurer and Sales Manager
Ionics Inc.

Cambridge, Massachusetts,
October 11, 1957.

SIR,—We also were greatly interested in (and pleased by) your articles on electro-dialysis in your September 6 and September 13 issues, and the following comments on Mr. W. E. Katz's letter are in order.

The article of September 13 neither states nor implies that an Ionics plant is a prototype, though the relevant sentence in the third paragraph could certainly be so misconstrued. I have no doubt that this was unintentional. William Boby and Co., Ltd., has no misconception on this point and regards an Ionics plant as a standard "off the shelf" piece of equipment. Field experience on electro-dialysis has not yet been gained by our company, but the Dutch organisation CTI-TNO which designed the stack, certainly has it, and we have the benefit of their wholehearted co-operation. Our contribution has been technique. We do have some field experience in water technology as we have been water treatment engineers since 1875. Incidentally each plant we sell could truthfully be described as a prototype, as our policy dictates that each should be "tailor-made" specifically for the job, and we have few standard catalogue plants.

The other questions are easily answered. The membrane size is 150cm by 40cm. The statement in the article that "the maximum potential difference employed is 217V" could be made more precise by stating that the maximum potential difference available is 217V, and this (or any lower voltage) can be applied to as many membranes as desired, up to the stack's capacity of 400, subject only to the current producing capacity of the generator. No further data are available for publication on the circulation rate of the diluate. A few additional points may be of interest. The power consumption graph in the article states "gallons per day for each full stack" and this refers to 400 membranes, not 200 as is stated below and also in the text. The power consumption anticipated at Tobruk is nearer 5kWh/1000 gallons than 7kWh/1000 gallons, and of course all figures refer to Imperial gallons. We are currently testing a new type of membrane which shows every indication of significantly reducing the published power consumption figures, as well as possessing ideal mechanical properties. The stack design is such that any type of membrane of suitable size is usable.

C. H. DE WHALLEY
Chemical Engineer
William Boby and Co., Ltd.

Rickmansworth,
October 24, 1957.

Book Reviews

Reinforced Concrete Designer's Handbook. Fifth edition. By CHARLES E. REYNOLDS. Concrete Publications, Ltd., 14, Dartmouth Street, London, S.W.1. Price 18s.

THIS latest edition of Mr. Reynolds' book is to be particularly welcomed since it coincides with the publication of the revised Code of Practice C.P. 114 for reinforced concrete. The author has found it possible to incorporate the more important emendations of and additions to the code in this book and gives a few worked examples to illustrate, for instance, the design of beams on the load factor method.

It is now twenty-five years since the first edition was published, and in this period great strides have been made in this type of construction. New approaches have been made both in the design office and on the job, and one wonders whether the time has not come for Mr. Reynolds to write a completely new book. This is not to say that the present edition is not a useful book ; it is, and without doubt will be as useful to present-day designers as all the previous editions have been—a *vade-mecum* for any designer. Nevertheless it is felt that it has been brought up to date by adding material rather than integrating it into the whole. The chapter on road design could well be rewritten in the light of other publications now available, and the treatment of joints in tanks could well be discussed in the light of modern experience; other examples could be chosen to illustrate the point.

No doubt time was not available to develop design charts for beams and columns based on the load factor method or to discuss the economy of it compared with the modular ratio method—which perhaps is a pity—and the increased stresses allowed for age at loading should be discussed in the text rather than appended to a table. Nevertheless, when all this has been said, the information necessary for a designer does appear to be all there, and this remains an excellent book.

Glass. By G. O. JONES. Methuen and Co., Ltd., 36, Essex Street, London, W.C.2. Price 8s. 6d.

IN this precisely written and clearly presented monograph, Professor Jones effectively reviews in six chapters and within 110 pages the present scientific knowledge concerned with the physics and chemistry of glass. This book does not seek to give technical details of either physical properties or manufacturing techniques, but the author has been careful to include the practical implications of the theoretical matter he discusses whenever possible.

The introductory chapter describes the "glassy state" and the underlying physical and chemical principles which account for the general properties of glass. A second chapter deals with the structural chemistry of glasses as elucidated by X-ray analysis and with the influence of chemical composition upon physical properties. The following chapter discusses crystallisation and stability in relation to structure, both in general terms and with specific reference to devitrification of silicate glasses and the influence of specific constituent oxides. Approximately half the book is devoted to two excellent chapters dealing with properties of glasses in the transformation range and with the behaviour of glasses under stress, subjects upon which the author's experienced work is well known. A final chapter deals briefly with the properties of metallic ions in glass. The book concludes with short appendices of tabulated glass compositions and with a few examples of special applications of glasses. There is a general bibliography and a list of references to papers of major interest.

In his preface the author suggests that judicious use of the index of this book would help the reader to find the answer to many practical questions about the manufacture and use of glass. It would perhaps be truer to say that an understanding of the content of this excellent book would enable the technologist to interpret the "solutions" of many practical problems and thus equip himself better to face up to future ones.

Transmission Circuits. By EVERARD M. WILLIAMS and JAMES B. WOODFORD. The Macmillan Company, 10, South Audley Street, London, W.1. Price 30s.

THIS book opens by developing the equations governing the steady-state distribution of current and voltage along a uniform transmission line when a sinusoidal voltage is applied at one end, in terms of the inductance and capacitance per unit length of the line. These general relationships are then discussed in connection with power, telephone and radio-frequency lines. Transient conditions when a "step-function" is applied to a loss-free line are considered. There is a chapter on artificial lines and filters.

In the first chapter it is pointed out that a complete treatment of the line is only possible by considering the electric and magnetic fields and that treating the line as a circuit is an approximation, though a very good one when the spacing between conductors is small compared with the wavelength. This point is returned to in an appendix, in which the electromagnetic field equations are developed for a simple case and compared with the circuit solution. This derivation shows how much more complex the field solution is, particularly if the resistance of the conductors is allowed for.

There are a number of examples, graded in difficulty and scope, at the end of each chapter, but no solutions or answers are given. The book is well produced and we only spotted one misprint. The use of small letters for the line parameters is unusual and, as a consequence, c appears in wave equations and does not mean the velocity of light.

Probably no material which is in this book is not readily available in a number of power and telecommunication textbooks. On the other hand, it is both convenient and educative to have in one volume the treatment of the line from both power and telecommunication aspects.

Books Received

Fundamental Principles of Transistors. By J. Evans, B.Sc., Ph.D., A.K.C. Heywood and Co., Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 45s.

Einführung in Die Ultrarotspektroskopie. Second Edition. By Dr. Werner Brügel. Verlag Dr. Dietrich, Steinkopff, Darmstadt, Holzhofallee 35, Germany. Price DM.49.

An Introduction to Fluid Mechanics and Heat Transfer. By J. M. Kay. Cambridge University Press, Bentley House, 200, Euston Road, London, W.1. Price 37s. 6d.

Iron and Steel Works of the World (1956–1957). Second edition. Edited by H. G. Cordero. Quin Press, Ltd., Birkett House, 27, Albemarle Street, London, W.1. Price per volume 147s.

Structural Design in Metals. Second edition. By Clifford D. Williams and Ernest C. Harris. The Ronald Press Company, 15, East 26th Street, New York, 10, N.Y., U.S.A. Price 8 dollars.

Technical Reports

Séminaire d'Aerothermique de la Faculté des Sciences de Paris (1954–55). Editor, E. A. Brun. Publications Scientifiques et Techniques du Ministère de l'Air, No. N.T. 63. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Ffr. 1200.—Beginning in 1954-55, the Science Faculty of the Sorbonne held a seminary in aerothermics—the common boundary between aerodynamics and thermodynamics—a subject which is of increasing interest because of the ever-greater speeds of aircraft, and the larger quantities of heat to be dissipated in such structures as atomic piles. At the eight monthly meetings, held under the chairmanship of Professor Brun, the following papers were presented and are here reproduced :—"Cooling of Walls by Injection" (J. Berger) ; "Heat Transmission by Liquid Metals Flowing in Circular Pipes" (M. Robin) ; "Superaerodynamics—Heat Transfer in a Rarified Gas" (M. Devienne) ; "On Certain Applications of the Theory of Boundary Layer Diffusion" (A. Oudart) ; "Steady Natural Convection from a Sphere with Small Excess Temperature" (P. Vernotte) ; "Interferometer Analysis of the Fine Structure of a Flow" (P. Guienne and F. Bouniol) ; "Velocity Profiles in the Boundary Layer in Compressible Flow" (G. Gontier) ; "Studies of the Experimental Techniques of the Boundary Layer in Compressible Fluid Flow" (Max Plan).

Application de la Micrographie Electronique à L'Etude de Certains Aspects de la Surface des Cristaux et de la Nature des Joints Intergranulaires dans le cas de L'Aluminium. By P. Bussy. Publications Scientifiques et Techniques du Ministère de l'Air, No. 325. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Ffr. 1200.—Investigations with the electron microscope give a resolution 10 to 100 times better than the optical microscope. However, dangers of misinterpretation of the results often arise owing to the uses of "replicas." The study of electrolytically polished aluminium crystals has shown that the appearance of the crystal surface varies considerably with its direction to the lattice. In order to interpret an electron microphotograph, it is necessary to show that it is not an antifact, i.e. due to an irregularity in the replica unconnected with the real structure of the metal. It then is necessary to correlate the picture with faults in the crystal on the one hand, and with the effect of the electrolytic polishing itself on the other.

The second part of the paper deals with new experiments on the intergranular corrosion of aluminium by hydrogen chloride, and the mechanism of the effect of the presence of traces of iron.

Die Messung von Flammen-und Detonationsgeschwindigkeiten bei der Explosiven Zersetzung von Azetylen in Rohren. By Dr. phil. habil. P. Hölemann, Ing. R. Hasselmann, and Ing. G. Dix. Forschungsberichte des Wirtschafts-und Verkehrsministeriums Nordrhein-Westfalen, No. 382. Cologne and Opladen : Westdeutscher Verlag, Ophovener Strasse, 1–3, Opladen. Price DM.8.10.—The authors describe experiments to determine the flame speed of acetylene in pipes of 4mm, 8mm and 16mm diameter and in a combustion chamber, under pressures ranging from 10 to 30 atmospheres. After an initial distance which varied according to conditions, between 100mm and 900mm, the combustion became a detonation, with flame speeds of the order of 2000m per second.

Modern Computing Methods : Notes on Applied Science. No. 16. National Physical Laboratory, Teddington, Middlesex. H.M. Stationary Office. Price 10s. 6d.—These notes on computation are based on the lectures delivered by various members of the staff of Mathematics Division, N.P.L., as part of a vacation course on "Computers for Electrical Engineering Problems," organised by the Electrical Engineering Department of the Imperial College of Science and Technology. Numerical methods are required in all branches of science, and the techniques are generally independent of the source of the problem. Edited versions of the lectures have therefore been presented as one of the N.P.L. series of "Notes on Applied Science."

Der Vorrichtungsbau : Part I. By H. Mauri. Berlin - Göttingen - Heidelberg : Springer - Verlag, Reichpietschufer 20, Berlin W35. Price Dm.3.60.—The present book on the design of jigs and fixtures appears as No. 33 in the series "Werkstattbücher" (workshop handbooks) of the Springer Publishing Company. Part I deals with the classification, purpose and fundamental components of jigs and fixtures from the point of view of the production and tool engineer and the user.

Some Current Practice With Computers

Some of the work of the Mathematical Services Department of the Royal Aircraft Establishment was demonstrated and explained during a recent visit to Farnborough. We record here the essence of an account given on that occasion by Dr. S. Hollingdale, Head of the Department, and include a note on an association of certain computer users.

THE Mathematical Services Department of the Royal Aircraft Establishment was formed nearly ten years ago. Its computing equipment now includes two fast electronic digital computers, a Hollerith punched-card installation, and a number of small analogue and digital instruments. The Engineering Division of the Department is concerned with the development of computing equipment and techniques, and also with data-processing systems and equipment. A selection of these is described later. The two fast digital computers are DEUCEs,* shown side by side in our title illustration. Instructions and numerical data are fed in on Hollerith cards, and the answers come out in the same form.

During the years between 1950 and 1955 the R.A.E. made considerable use of the ACE computer at the National Physical Laboratory—this was the prototype of the DEUCE. It was

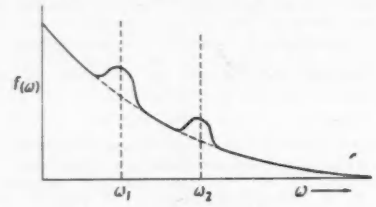


Fig. 1—Time series analysis

therefore natural to place the first two DUECEs at the N.P.L. and the R.A.E. These were installed in 1955. Within a year the load on the R.A.E. machine (known to her friends as "Gert") had increased so much that a second machine ("Daisy") was ordered in August 1956 and was delivered in December. Up to the end of September 1957 a total of 6240 hours of effective computing had been completed, an average of about 46 hours per week per machine. The machines are normally operated until about 10 p.m. Mondays to Fridays, with occasional all-night or weekend working. About two hours each day per machine is devoted to routine testing and servicing. The overall operational efficiency (the ratio of the "good" time to the total "switched on" time, excluding the two hours daily maintenance) is just over 90 per cent for Daisy and about 85 per cent for Gert.

The DEUCE is very flexible, and it can be switched rapidly from one job to another. As many as twenty different jobs are often handled on one machine during the course of a normal working day. The R.A.E. DEUCEs have been used on (1) aerodynamic wing design (camber and twist), (2) wave drag of supersonic wings (the drag due to shock waves), (3) aerodynamic design of supersonic wind tunnels, preparation of punched tapes for controlling the shapes of the tunnel walls, (4) machine settings for manufacture of wind tunnel models, (5) reduction of wind tunnel measurements, (6) determination of normal modes and frequencies of oscillation of aircraft structures, (7) evaluation of aerodynamic derivatives (forces and moments on an oscillating wing), (8) prediction of critical flutter speeds, (9) analysis of fatigue and gust data obtained in flight, (10) helicopter resonance studies, (11) analysis of data from speed and height record attempts, (12) work on electro-magnetic wave propagation, (13) analysis of automatic control systems, (14) statistical investigations; design of experiments and analysis of results, and finally (15) weapon studies. Brief notes on items (1), (3), (8), and (9) are given below.

Supersonic Wing Design.—In designing a supersonic aircraft wing of given planform to have a prescribed lift distribution, the parameters one uses are the chordwise *camber* and spanwise *twist*. In this case the design calculation involves the evaluation of the chordwise slope, dZ/dx, at 1000 points (x, y) from the formula

$$\frac{dZ}{dx}=\lim_{Z\to 0}\frac{1}{4\pi}\int_{\eta_0}^{\eta_1}[A(\eta)+B(\eta)\{x-C(\eta)\}]\sqrt{\{x-C(\eta)\}^2-\beta^2\{y-\eta\}^2}\,\frac{(y-\eta)^2-Z^2}{\{(y-\eta)^2+Z^2\}^2}\,d\eta$$
$$-\frac{\beta^2}{4\pi}\int_{\eta_0}^{\eta_1}B(\eta)\operatorname{arc\,cosh}\left\{\frac{x-C(\eta)}{\beta\sqrt{y-\eta}}\right\}d\eta$$

In this formula $A(\eta)$, $B(\eta)$ and $C(\eta)$ all depend upon the planform of the wing; β depends upon the Mach number. The limiting and integrating operations are not commutative, and special formulæ were derived to perform the two in one process. Computation of a single wing takes about three hours on DEUCE. A survey of about thirty wings is in progress. It is estimated that this would take nearly fifteen man-years using electric desk calculating machines.

Supersonic Wind Tunnel Design.—In a supersonic wind tunnel the Mach number of the air flow (given sufficient power input) depends only on the shape of the walls upstream of the working section. The 8ft by 8ft 80,000 h.p. tunnel at R.A.E. Bedford† has flexible walls, and these are constrained to the desired shape by a series of jacks (thirty pairs to each wall) which are controlled by a set of punched paper tapes. Once the operator has set the desired speed, the shape of the tunnel is adjusted automatically. The R.A.E. DEUCE was used (*a*) to solve the aerodynamic equations governing the air flow, and hence to calculate the required wall shapes, for thirteen different Mach numbers between 1·0 and 2·8, (*b*) to compute the extension of the jacks to give these wall shapes, and (*c*) to subtabulate these jack extensions to a very fine interval in Mach number (18,000 steps between M.1 and M.2·8), so that the speed can be varied by very small steps. Finally, the results were copied from the cards produced on DEUCE on to the paper tapes used to control the jacks.

Flutter Calculations.—An aircraft wing has to be flexible, and constitutes a simple vibrating system. An aileron rotating about its hinge is another. Two such systems can couple, setting up a self sustaining oscillation which at a certain ("critical") air-speed will be just maintained. At still higher air-speeds such an oscillation could grow in amplitude and catastrophic failure might occur. The calculations are very complicated due to the interactions between the aerodynamic and elastic forces, and involve lengthy manipulations of matrices. The principal questions to be answered are (i) what are the modes, frequencies and degree of damping of the oscillatory movements, (ii) what is the critical flutter speed, and (iii) what structural modifications must be made to ensure that the critical flutter speed exceeds the maximum speed of the aircraft by a comfortable margin? It is estimated that such calculations as are now performed on DEUCE would take 300 times as long on conventional desk calculating machines.

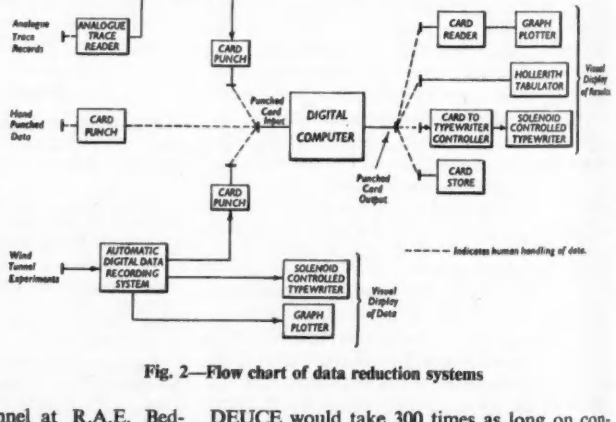


Fig. 2—Flow chart of data reduction systems

Time Series Analysis.—Where an elastic structure with several well defined natural frequencies of oscillation is continually subjected to random stimuli, such as occur in rough flying conditions, these natural frequencies are camouflaged. There are statistical procedures for revealing these hidden frequencies. If the air-

* Manufactured by the English Electric Company, Ltd. THE ENGINEER February 25, 1955, page 266.

† See THE ENGINEER July 5, 1957, page 21.

craft has a natural period, τ, this will show itself as *correlation* between the value of x at any time t, and those at times $t+\tau$, $t+2\tau$, &c. A quantity known as the *auto-correlation coefficient*, $r(k)$, which expresses the average degree of correlation between values of x which are separated by a time interval, k, is computed for a number of values of k. Given a set of values of $r(k)$, a further quantity $f(\omega)$ can be calculated, which when plotted against the frequency, ω, might look like Fig. 1. The peak values ω_1 and ω_2 are the natural frequencies of the aircraft. The dotted line tells us something about the (continuous) variation with frequency of the energy of the atmospheric turbulence.

If we have 1000 observations of x, then the evaluation of $r(k)$ for 100 values of k involves 102,200 multiplications and 104,000 additions, together with 100 divisions and square roots. DEUCE carries out this calculation in about twenty minutes, compared with an estimated two months using desk machines. The last stage, the calculation of $f(\omega)$, takes about one minute. Extensive calculations of this kind were first performed by the R.A.E. on the ACE during the "Comet" investigation of 1954. The behaviour of many aircraft has since been subjected to the same analysis.

The technique is applicable to time series arising from many different sources other than mechanical vibration. Examples which have been dealt with at the R.A.E. are errors in radar tracking systems, radio and instrument "noise" which interferes with the behaviour of electronic devices, and meteorological data.

DEUCE Users Association

Concurrently with the building and installation of the machines at Farnborough, several other DEUCE computers were manufactured by the English Electric Company, Ltd., and supplied to various other organisations, the majority of them to the aircraft industry. It was obvious that work might be duplicated. To avoid this, the English Electric Computing Centre at Stafford, after the installation of their machine, prepared small programmes (called sub-routines) covering many common requirements. An example is a sub-routine to evaluate the cosine of any given angle to a specified degree of accuracy and another is to evaluate the logarithm of a given number (experience has shown that it is preferable to compute these functions when required rather than to store complete sets of possible results and "look up" what is wanted). These sub-routines were to be made available to all DEUCE users. It was decided to extend this scheme by forming a users' association. The members of the Association have been encouraged to submit to the library, maintained at Stafford, all their appropriate sub-routines. Formal reports are written on the operations involved. The reports are attached to summary cards which give enough detail for a possible user to assess them. Each of these summary cards carries an index number which can be used as a filing reference in the individual user's library. We understand from the English Electric Company that the sub-routine library at Stafford now contains more than 300 different sub-routines. In addition to this there is a DEUCE programme library which is of similar volume and contains programmes which are complete in themselves. As an example of this, there is a programme which will solve large sets of simultaneous equations. Another allows the evaluation of the complex roots of any polynomial expression.

A further facility recently developed is called the DEUCE "Alpha" code, and is intended for use by those unfamiliar with conventional programming methods, but familiar with desk machine calculation. Since DEUCE has to convert the user's language into its own internal language, and quite a considerable time is needed for this, the "Alpha" code effectively reduces machine speed. Consequently, the code is generally used only for those problems which have to be solved once or a few times, and where programming effort is considered to be more valuable than machine time. Work is now proceeding on an interpretative programme which will convert the user's own set of punched cards into a more efficient programme on another set of punched cards.

Processing of Experimental Data at R.A.E.

Aeronautical research yields quantities of experimental data, such as continuous traces on cine-film or rolls of paper, photographs of instruments, oscillograph records or sets of figures recorded manually. All this material has to be interpreted, analysed, and the results displayed. This entails a good deal of computing (much of which is now done on DEUCE), but a survey made a few years ago revealed that the junior "computing" staff in R.A.E. spent only half their time doing sums. The other half was spent transcribing information from one form to another. During the last five years the Mathematical Services Department has developed a range of devices for making the whole process, from recording to display, as automatic as possible. Problems and requirements are constantly changing, so flexibility is necessary. A number of separate units has been developed which can be selected and assembled according to particular needs. The complete process may conveniently be broken down into three stages: (1) transcribing the raw data on to Hollerith cards, for input to DEUCE; (2) computing, and (3) displaying the results in a convenient visual form. Each of these stages is made as automatic as possible, but manual operations are allowed between the stages in order to achieve the desired flexibility. Fig. 2 shows a flow chart of the general scheme with particular reference to three kinds of experimental record: on punched film, as continuous traces, and from wind-tunnel measuring instruments.

Wind Tunnel Recording.—The old procedure was to photograph on cine-film the various instruments measuring the forces, moments, and pressures, on the model in the wind tunnel. The photographs, after being developed and printed, were read by one operator and a second one wrote down the figures. Computing was done on desk calculating machines, and the final results were plotted by hand. With this system there was a delay of about six weeks between completing the tests and delivering the final answers—half the time being spent in computing and half in transcribing data. All the larger tunnels, at Farnborough and Bedford, are now fitted with automatic data-recording equipment; the six weeks has been reduced to about three days, tunnel operating staff has been halved and computing time virtually eliminated.

The readings of the tunnel measuring instruments, usually either strain gauges or pressure manometers, are first converted to shaft rotations and then into digital electrical signals. A number of such digital outputs is scanned and the signals are fed, after some decoding, to: (*a*) a "Type-29" Hollerith programme board card punch, which prepares a pack of cards in a form suitable for direct input to DEUCE, and (*b*) a solenoid operated typewriter. The whole process up to this stage is fully automatic. The punched cards are then brought to DEUCE, where the necessary computing is carried out according to a few standard programmes kept for the purpose. DEUCE punches out a further pack of Hollerith cards containing the computed answers, which are carried into the next room and fed to an automatic printing or plotting device to give a record in a convenient form.

Analysis of Trace Records.—Experimental data, particularly from flight tests, are often obtained as traces on film or paper. The department has developed a simple "trace reader" for analysing this kind of record. The equipment is semi-automatic in that an operator must "read" the trace by aligning a marker upon it at the appropriate intervals. When he has done this, the equipment automatically emits the coded pulses which are the digital representation of the value read from the trace. These pulses can operate, as before, either a card punch or a typewriter. Several trace readers are in use, and it is found that operators quickly settle down to a rate of about 1000 readings per hour.

Kinetic Heating Simulator.—A special digital computer‡ controls a simulator that heats or cools a test structure (which might be all or part of an aircraft or missile) in the same manner as it would be heated or cooled during some specified high-speed flight. The computer solves the equation:

$$e=A_0X_0+A_1X_1+A_2X_2+A_3X_3+A_4X_4$$

to give e the increment (positive or negative) of heat flow which is required at any moment. The Xs are the readings of instruments (e.g. thermometers). The As represent the varying conditions of flight, and are fed into the controlling computer on punched film. The Mathematical Services Department calculates (on DEUCE) the coefficients A for successive instants (these depend both on the flight path to be simulated and on the structure), and prepares the necessary punched film. The information on the DEUCE output cards is transcribed on to punched film for input to the special computer.

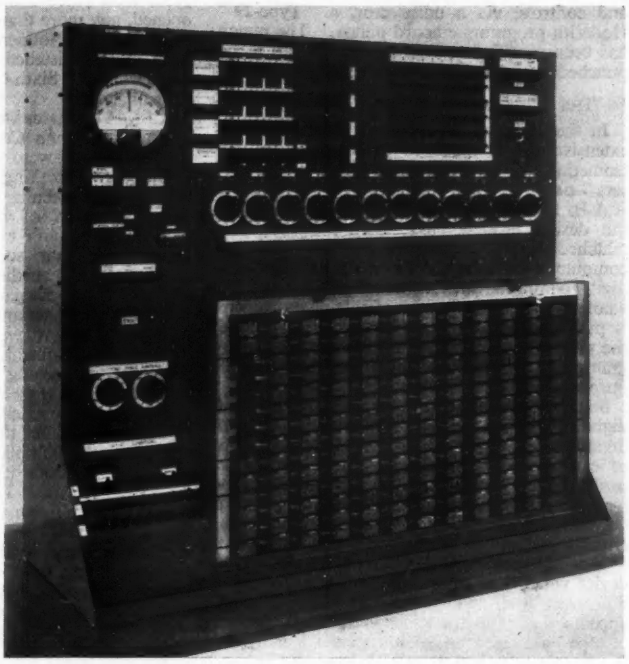


Fig. 3—Demonstration model of R.A.E. digital differential analyser. This has only three integrators, and is not big enough for serious work. Electro-mechanical relays were used to accelerate design and construction of the model, but will not be used in the full-scale machine

Digitisers.—The digitiser forms part of many of the data-handling systems at R.A.E. It translates the representation of a quantity from an analogue to a digital form. For example, analogue representation may be either a shaft rotation or a linear displacement which, by driving a commutator, produces a parallel electrical output on a number of lines. The digital output is represented in the cyclic progressive binary coded decimal code, which has certain technical advantages. Considerable effort has been devoted to the design of these digitisers, mainly in order to obtain high accuracy and long life in a small, cheap item, so that it may be used in large numbers in any data-handling system. An instance of a linear displacement digitiser is that which is embodied in the trace reader, and which divides a scale length of 8½in into 1000

‡ English Electric Company, Ltd.

steps. A single-turn digitiser is also used, which divides a revolution into 1200 steps coded 0–1199 ; similar digitisers dividing a revolution into 1000 steps and into 1200 steps coded from −30 to +30 in steps of 0·05 are also being produced.

Card-Operated Film Punch and Tape Punch.—The machine will transfer information from Hollerith punched cards to either a twelve-hole, 35mm film or a five-hole teleprinter tape. A "Type-129" Hollerith programme board verifier is used as a card reader, and a device operating at seven and a half lines per second punches the information on to the film. The film punch was developed at R.A.E., in the first instance for airborne use. Its speed may be varied from 7½–15 lines per second, with a recording density of twelve holes per line, ten lines per inch. Conversion to photographic recording on the film, in place of punched holes, is in the experimental stage. This is the obvious step since reverse transcription (see below) is by photoelectric means.

Film-Operated Card Punch.—This equipment performs the reverse transcription from twelve-hole, 35mm film, to Hollerith cards. The film is read photoelectrically by a transistorised unit and controls, via a uniselector, a "Type-29" Hollerith programme board punch. The punch has been modified to enable twelve holes to be punched in each column of a card.

The Digital Differential Analyser

In the design of aircraft and guided missiles, extensive use is made of analogue computers (sometimes called "electronic differential analysers" or simulators), the largest of which in the R.A.E. is TRIDAC. Increasing refinements in the design process have, however, not been matched by similar improvements in analogue computers. Recourse to a general-purpose digital computer, such as the DEUCE, is not the whole answer, since its way of solving a problem is pure computation, only indirectly related to the physical system under examination. If programmed to imitate a simulator, the general-purpose computer becomes intolerably slow.

Some of the speed can be retrieved by making a digital computer specially for the job, called a digital differential analyser. The development of computers of this kind is the most recent project of the Engineering Division of the Mathematical Services Department. Fig. 3 shows a very simple demonstration model of what, on a larger scale, will eventually be a fast computer.

The basic component of such an analyser is a device which integrates approximately by finite differences and, as far as the user is concerned, appears similar to the wheel-and-disc integrator of the old mechanical differential analyser. Suppose the integrator has an output Δz, an input Δx, and one or more inputs Δy. Δy is first added to y (the total of all previous Δy inputs) and Δz is formed so that this equals $y\Delta x$ on the average. In fact, instead of having complete facilities separately for each integrator, which would be too expensive, a common computing circuit is provided which is used in turn by all integrators, only storage being provided separately for each variable. The operation is therefore similar to that of a general-purpose digital computer with the special arrangement that the only part of the programme not predetermined is the interconnection of the integrators, as is the case with a conventional differential analyser.

The department is developing an electronic digital differential analyser which, it is expected, will compare well with proprietary electronic analogue differential analysers now in use in the R.A.E. It should, of course, be much more accurate and allow precise repetition of results. Further, the fact that the Δx input to an integrator is explicitly available means that the techniques of the mechanical differential analyser can be used. In particular, a multiplier can be made from two integrators, since

$$\Delta(y_1y_2)=y_1\Delta y_2+y_2\Delta y_1.$$

Again, two integrators can be used to generate the sine and cosine of a variable. In general, whereas non-linear operations require special devices in the conventional electronic analyser, in the digital machine they are provided by a suitable grouping of standard integrators. This permits a big advance in accuracy, flexibility and cheapness.

International Astronautical Congress

There took place last month in Barcelona the Eighth International Astronautical Congress. The President of the International Astronautical Federation for 1956–57, Dr. L. Shepherd, of the British Interplanetary Society, is to be succeeded by Mr. A. G. Haley, of the American Rocket Society. A committee to study the legal implications of flight beyond the atmosphere is to include Russian representatives.

DELEGATES travelling to the Eighth International Astronautical Congress, held in Barcelona from October 6 to 12, were expecting to hear reports during the Congress of the success of Project Far Side, an American plan to fire a research rocket 4000 miles away from the Earth by means of a balloon launching. But it was not until five days after the Congress that it was learnt that four Far Side attempts had been failures, owing to unfavourable weather conditions. Instead, the delegates assembled with the knowledge that Russia had succeeded in establishing the first artificial satellite of the Earth. It was surely no coincidence that this event took place two days before the Congress opened, any more than it was a coincidence that two years ago President Eisenhower's announcement of the existence of Project Vanguard was made whilst the Sixth Congress was in progress at Copenhagen.

Russian delegates were present at Copenhagen and at last year's Congress in Rome, and on both occasions were centres of interest, being regarded as something of an enigma. They also occupied the peculiar (and strictly unconstitutional) position of being delegates from an official commission rather than from an independent national society. With the Soviet satellite already hurtling across the sky, interest in the Russian delegates and what they had to say mounted higher and higher. But remarkably little information was given concerning the satellite, or its launching vehicle, or future plans. Reticence concerning the launching vehicle is understandable, however, for the surprisingly high mass of the satellite (reported to be 184 lb, or about nine times that of the proposed "Vanguard" satellite) implies that the take-off mass of the rocket is about 100 tons, thus placing it in the I.C.B.M. class. This ties in with the Soviet claims made in August that they had successfully fired an I.C.B.M.

The Russian delegation presented five papers at the Congress, but these were concerned mainly with general principles and were mostly mathematical in nature. One dealt with the establishment of an artificial satellite in its orbit, another with the determination of its lifetime, and a third with its use for the investigation of primary cosmic radiation. V. A. Egorov submitted a paper on the dynamics of a flight to the Moon. Mrs. A. T. Masevich, a young astro-physicist who also acted as interpreter, described the preparations in the U.S.S.R. for the visual observation of artificial Earth satellites. Visual observation will become of importance when the satellite's batteries have given out and in the last stages of its flight. Groups of observers have been organised along much the same lines as the "Moonwatch" teams set up in the West for observing "Vanguard." Mrs. Masevich presented the Spanish society (Agrupacion Astronautica Española) with one of the special telescopes built in Russia for observing the satellite. Here, again, this was essentially similar to the instrument recommended for construction by amateur "Moonwatch" teams, but had the much better style of a factory-produced article. Mrs. Masevich remarked that when they first asked the instrument factory to produce the telescope to their design three or four months ago, they met with considerable opposition, the technicians wanting to substitute something quite different. Their attitude changed when they learnt what the instrument was for and how it was to be used, co-operation was achieved, and the factory now has an observation team of its own.

The first four of these papers were also printed in two special supplements to the periodical *Uspekhi Fizicheskikh Nauk*, which the leader of the Russian delegation, Professor L. Sedov, presented to the national astronautical societies. These supplements contained seventeen astronautical papers, the subjects dealt with including the uses of artificial satellites, silicon solar batteries as power sources for satellites, and rocket investigation of upper atmosphere conditions.

The Russians may have "scooped" the U.S.A. with their satellite, but at least an American holds the honour of having personally experienced conditions at the frontier of space. He is Major David G. Simons, M.D., Chief of the Space Biology Branch of the Aero-Medical Field Laboratory, Holloman Air Force Base, New Mexico, who spent over a day at a height of 100,000ft last August, in a specially designed capsule suspended from a large balloon of the "Skyhook" type. This project was known as Man-High II. Mr. Otto C. Winzen, of Winzen Research, Inc., described the balloons he had developed, made from 0·0015in gauge polyethylene film, and the capsule built to provide Major Simons with all the necessities for a thirty-hour flight. Major Simons reported his observations during the flight (he is known to have been hit several times by high-energy primary cosmic radiation but as yet no biological effects have been observed).

In the present state of the art, it was natural that many of the forty-odd contributions should be concerned with satellites and orbital vehicles. R. P. Havilland, of the General Electric Company, U.S.A., considered the requirements for a communication satellite, i.e. a base or relay station for telephony, radio and television systems. This application was first proposed by A. C. Clarke some twelve years ago (*Wireless World*, October, 1945, pages 305–308). The preprint of the paper, "Optimisation Considerations for Orbital Payload Capabilities," by H. H. Koelle (formerly a leading member of the Gesellschaft für Weltraumforschung, now Chief of the Preliminary Design Section, U.S. Army Ballistic Missile Agency, Huntsville, Alabama) showed that he had made a good estimate of the mass of the Russian satellite, based on a consideration of the available military components. The preprint also includes a useful bibliography on orbits and trajectories, carrier vehicles and satellites. Björn Bergqvist, research leader of the Swedish Interplanetary Society, investigated the weight of minimum cost orbital ferry vehicles. R. E. Roberson, of North American Aviation, Inc., outlined the problems in controlling the attitude of a satellite vehicle. Norman V. Petersen, of the Sperry Gyroscope Company, dealt with recovery techniques for manned Earth satellites. It seems that there will now be a race between Russia and America to be the first to place a manned vehicle in orbit about the Earth, and the main difficulty is going to be the retrieval of the pilot (although, as Mr. Petersen hinted, some pilots may not consider this necessary). He reviewed the retrieval proposals that have already been made and then suggested recovery by use of high-speed aircraft.

Until a British engineer, K. W. Gatland, suggested the establishment of minimum Earth satellites of the type now in use (a proposal made in 1951 at the Congress organised in London by the British Interplanetary Society), ideas concerning artificial satellites envisaged quite large structures assembled in space. These were known as space-stations. A particularly grandiose proposal of this nature (Project Meteor) was made last year at the Rome Congress by Darrell C. Romick of the Astronautics Group of Goodyear Aircraft Corporation. During the intervening year, the Group has continued its work and has now produced considerably watered-down proposals ("Meteor Junior"), involving the construction of a ferry rocket vehicle comparable in size with the "Atlas" I.C.B.M. Another development of the future was treated

mathematically by W. B. Klemperer and E. T. Benedikt, of the Douglas Aircraft Company, Inc. Their paper, "Selenoid Satellites," was concerned with bodies having such an orbit that they remain in a constant aspect relationship with Earth and Moon. This constitutes a special case of the three-body problem, one shown to be soluble by Lagrange in 1772.

As is usual, there were several contributions relating to propulsion. W. N. Neat, who is in charge of rocket propulsion at the De Havilland Engine Company, emphasised the need for rocket engines capable of giving thrusts variable over a considerable range. The effect of throttling on performance and regenerative cooling of the combustion chamber were indicated. For long journeys in space itself ionic propulsion systems become theoretically possible; no practicable system has yet been devised, but papers by Ernst Stuhlinger and J. J. Barré, respectively, dealt with the design of ion rockets. Monsieur Barré also gave a second paper, in which he considered the nuclear rocket, which operates by utilising the heat from an atomic pile to heat up a working fluid, which is then discharged as a jet of gas. Nuclear-propelled rockets are likely to be developed within the next few years; America, Russia and Britain are working on this type of reactor. The development of an efficient nuclear rocket is an important task for astronautics, since it would make journeys to and from the planets quite feasible. Using only chemical propellants, even the comparatively short journey to the Moon and back would require the employment of complicated refuelling techniques.

Of less immediate interest was a paper by Dr. J. M. J. Kooy, though it aroused memories of the Dingle-McCrea controversy on time dilation in space-flight at high velocities. It concerned the relativistic mechanics of rocket flight.

Peter E. Glaser, of Arthur D. Little, Inc., reviewed methods of generating temperatures up to 30,000 deg. K., including various types of furnace, plasma jets, and the high intensity arc. Such temperatures are of interest to astronauts because the thrust of a rocket engine increases with increasing chamber temperature. The experiments in progress may lead not only to new means of producing high chamber temperatures but also to the development and testing of new materials of construction for the combustion chamber. Improved materials of construction are also required for the vehicle structure itself, if manned recoverable satellites or ferry vehicles are to be built. In the return to Earth they will encounter the so-called heat barrier. Starting with the orbital speed of about 18,000 m.p.h., they will speed up as they fall to the Earth and will become heated by friction with the atmosphere. It has been estimated that both the U.S.S.R. and "Vanguard" satellites will be raised to incandescence as they spiral in, and will burn away. For manned vehicles or recoverable instrumented satellites, improved high-temperature materials offer one way of combating this heat barrier (a similar problem will be encountered with the I.C.B.M. during re-entry) and facilitating recovery. The problem of recovery of orbital vehicles has already been mentioned; recovery of two other types of vehicle received special attention. R. T. Patterson, of the Glenn L. Martin Company, presented the results of a study to determine the feasibility of recovering the payloads from very-high-altitude (200–2000 miles), near-vertical trajectories. These conditions involve entry velocities of upwards of 14,000 m.p.h. and decelerations of at least 109 g, but it is concluded that recovery is possible. Carl Gazley, Jnr., and David J. Masson, of the Rand Corporation (a research organisation established by the U.S. Air Force, which has produced reports on such subjects as Soviet astronautics, materials for high-speed aircraft, the theory of games, &c.), considered the recovery of a circum-lunar vehicle. Aerodynamic heating during ascent is of less importance than that during re-entry, but a mathematical paper by Angelo Miele, of the Douglas Aircraft Company, Inc., was concerned with its effect in the determination of an optimum burning programme for a rocket.

Flight to or around the Moon requires only a relatively small increase in velocity over and above that given to the Russian satellite. This has led Professor S. F. Singer, of the University of Maryland, to suggest that H-bombs should be exploded on the Moon, partly as a means of testing the bombs and partly for scientific purposes (by observation of visible effects, radiation and lunar material thrown up and captured by the Earth). This proposal is not one that finds favour with astronauts in general. First, there is doubt about whether our navigational techniques are sufficiently advanced for us to guarantee that the Moon would be hit, and any near miss might result in the missile circumnavigating the Moon and returning towards the Earth. Secondly, it would be even easier to test the bomb in free space. Most important of all, it would be rather a pity if man's first action on another world were to be destructive. If anything is to be sent to the Moon, an instrument package is preferable. An H-bomb explosion might destroy more scientific information than it provided.

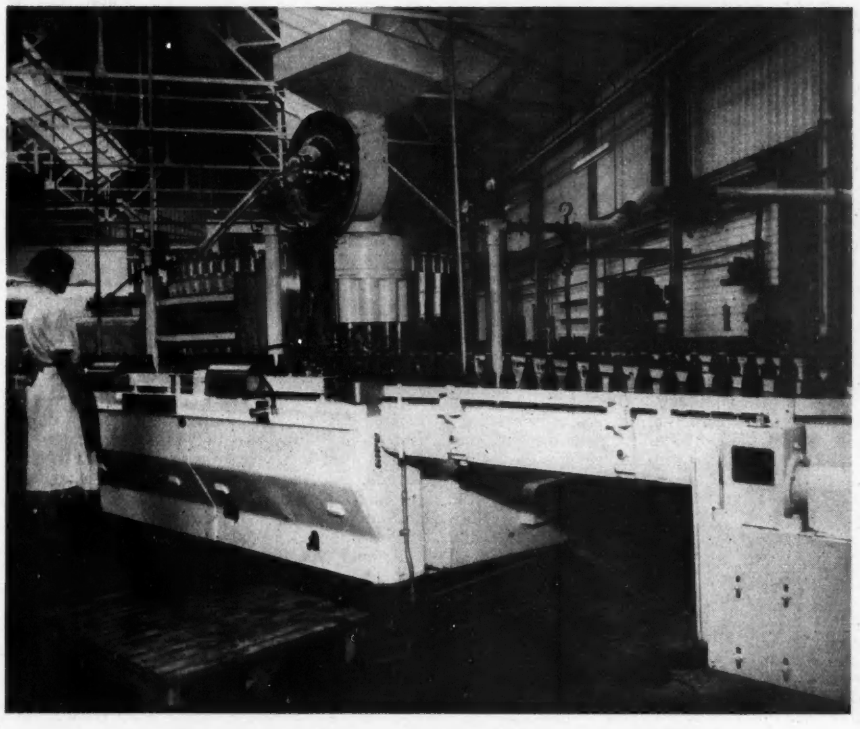
Colonel W. O. Davis outlined some current research trends in astronautics, and particularly the research programme of the U.S. Air Force Office of Scientific Research. One particular aspect of U.S.A.F. research was described by three members of the School of Aviation Medicine (S. J. Gerathewohl, O. L. Ritter and H. D. Stallings, Jnr.); this was the production of the weightless state in jet aircraft by flying in parabolic arcs. Comparison was made of the suitability of various types of aircraft for this purpose. The longest period of weightlessness yet recorded was forty-three seconds. F. L. Whipple, of the Smithsonian Astrophysical Observatory, submitted two papers on the meteoritic risk to space vehicles and on the accuracy of orbits determined by ground-based optical tracking. Andrew G. Haley, a noted aeronautical lawyer and General Counsel for the American Rocket Society, stressed the imminent need for an international space law, and a similar recommendation was put forward by the Sociedade Interplanetária Brasileira, which proposed that the upper limit of national sovereignty should be that altitude to which air-breathing vehicles could ascend.

Mr. Haley was elected President of the International Astronautical Federation for 1957–58. The next Congress will be held in the Netherlands in August, 1958, and it is probable that in subsequent years meetings will be in Moscow, Stockholm, New York and Warsaw.

Brewers' Machinery

The Brewers' and Allied Traders' Exhibition, which was held at Olympia last month, besides dealing with the raw materials supply, provided a general survey of the developments in machinery which have been made during the last three years. Particular emphasis was on filling, washing and handling machinery, together with other ancillary equipment.

THE Brewers' and Allied Traders' Exhibition, which opened on September 30 and closed on October 4, was held at Olympia, London, and reflected the progress made in machinery and materials in the three years which have passed since the last exhibition was organised. A number of new machines were on view and included a cask washing machine, by G. Hopkins and Sons, Ltd., North Road, London, N.7, which is fully automatic and able to deal with casks at rates varying from 180 to 350 per hour according to size. The machine, of fabricated steel construction, is provided with a cask carriage and supporting chocks carried on ball bearing roller assemblies which permit two-way horizontal movement independent of vertical motion. A double-acting hydraulic ram imparts vertical movement to the cask cradle while a double-acting hydraulic cylinder provides horizontal movement through a rack and pinion assembly. In operation the carriage is moved backwards horizontally and automatically centres the supporting chocks at the washing stations; it is then raised lifting the casks at the same time, and moves forward to align the casks above the next set of nozzles, and then lowered. There are



Bottle filling and crowning machine—Vickers-Armstrongs (Engineers), Ltd.

thirteen stations along the length of the machine. From No. 1, the receiving station, the casks are transferred to the bung location station, and on to the preliminary rinse nozzles at stations Nos. 3 and 4, followed by external washing and brushing at No. 5, after which is another bung location station. From this point the cask passes to a series of six washing stations, where any combination of steam or hot liquor can enter the cask. Finally there is the discharge station.

Among the items shown by Vickers-Armstrongs (Engineers), Ltd., was a Worssam filling and crowning unit, illustrated herewith, which can handle half-pint bottles at a rate of 2000 dozen per hour. A water-balanced counter-pressure system of filling is used and to eliminate the shock inherent in the "stop-operated" star wheel or latch mechanisms a simple form of pneumatic actuation is employed for the filling heads. All controls are placed within easy reach of the operator. A slat chain conveys the bottles which are ploughed off for filling and capping and cut-outs operate on the pneumatic circuits of the clutches and brakes of the drive to safeguard the mechanism in the event of a bottle falling. Air is supplied through a preset reducing valve at about 45 lb per square inch to the bottle lifts; the twelve-head crowner is mounted on the same base plate as the filling machine and driven by the same motor through a pneumatic clutch. Power is provided by a 4 h.p. motor driving through a variable speed pulley. On the stand of R. W. Webster and Co., Ltd., Waltham Cross, Hertfordshire, was a brushless hydro-soaker bottle washing machine, which can be fitted with magazine or automatic distance pattern loaders. From the loading station the bottles are conveyed to a point where they are given a prerinse at 90 deg. Fah., after which they follow a track consisting of a series of loops. At each the bottle is immersed in a detergent soak tank at temperatures ranging from 120 deg. to 160 deg. Fah., and is drained before entering the next tank. After emerging from the final detergent soak the bottles are subjected to detergent jetting at 120 deg. Fah and afterwards allowed to drain before entering the next section, where they are subjected to recirculated water jetting before being given a final cold water rinse prior to discharge. A smaller hydro-soaker washer was shown by the Barry-Wehmiller Machinery Company, Ltd., 258, Westminster Bridge Road, London, S.E.1. This machine is hand loaded and has a capacity of 3000 bottles per hour. The bottles are given a prerinse with warm water before passing neck-up through a moving stream of a 3 per cent alkali solution at a temperature of 135 deg. Fah., followed by an external scouring by a hot caustic spray. Now neck down, the bottles are centred over caustic jets which clean the interiors and then, after draining, the bottles are sprayed internally and externally with a warm mild alkali solution followed by similar treatment with fresh water before discharge. The machine measures 18ft 7in in length by 4ft 6in in width by 6ft 7in in height and is powered by a 1½ h.p. motor for the drive and a 3 h.p. motor for the pump.

An "in-line" decrating and recrating machine, which has been developed by Dawson Bros., Ltd., Gomersal, Leeds, to reduce bottle handling costs, was on view. The machine is automatic: each movement is synchronised with the stops on the crate conveyors, while operation is by compressed air at 60/80 lb per square inch. The head is fitted with individual bottle grabs, consisting of self-centring legs, which grip the bottle underneath the rim, and has a horizontal forward and reverse movement and also a vertical movement. When decrating a clamp locks the crate in position: the grab head is lowered and when the stroke is completed each bottle in the crate is automatically gripped. An upward movement of the head lifts the bottles clear and the head slides away on guides to the unloading stage, where the grips are released: at the same time the head lifts and allows the bottles to fall base down on to the scrambling table ready for conveying to the washing machine. For recrating the cycle of operations are reversed and the bottles which have been marshalled into their respective lanes are transferred from the table to a crate.

Aldersley Engineers, Ltd., of Tettenhall, Wolverhampton, showed an example of a "Vac-U-Vator," which the company build under licence. This is a portable self-contained unit, mounted on a four-wheeled chassis, which can convey up to 1600 bushels of grain per hour over a distance of 250ft and can also elevate to a height of 70ft. The machine has a basic weight, less piping, of 1·9 tons, a length of 117in, a breadth of 86in and a height of 108in; it is available powered by either a radiator-cooled diesel engine, developing 62 b.h.p. at 2000 r.p.m., or an electric motor. For the diesel powered unit the engine, by means of six "V" ropes, drives a three-stage high-pressure centrifugal fan, which is capable of delivering air against a pressure of 85in water gauge. Air delivery will normally vary from 1200 to 3000 cubic feet per minute through a fan speed ranging up to 4000 r.p.m. On the suction side the pipes deliver the grain into a heavy duty cyclone, in which the grain is separated from the air and passes into an airlock and thence into the exhaust piping for delivery. The rotary airlock is sited below the cyclone and prevents the delivery air from the fan from circulating back up the cyclone. The machine is supplied with lengths of rigid and flexible pipe, elbow bends, &c., all of 8in diameter, and a derrick complete with rope sheaves to handle the piping.

On the stand of Mojonnier Bros. Company, Drayton Road, Tonbridge, Kent, there was shown a "Carbo Cooler" suitable for the simultaneous cooling and carbonation of 450 gallons of water per hour. The "Carbo Cooler" tank has polished inner and outer shells and is insulated with cork; inside is mounted the water distributing trough, corrugated cooling plates, carbon dioxide inlet assembly, and anti-swirl baffle at the tank outlet. Stainless steel bolts secure the top cover to the tank, while a neoprene gasket ensures a gastight fit, and the base of the unit is fabricated from mild steel and zinc sprayed. Mounted on the base is the supply pump, which is capable of operating against a head of 75 lb per square inch. Ammonia is the refrigerant used: an automatically operated back-pressure regulating valve with a manual opening stem is used to maintain a constant temperature of the refrigerant in the cooling sections, irrespective of fluctuations of the temperature of incoming water supply. A surge drum is employed to feed the liquid refrigerant to the cooling plates and to ensure that only gas is delivered to the compressor. A recorder-controller instrument records the temperature of the product as it leaves the reservoir and gives precision control of the carbonating pressure by operating a diaphragm valve in the carbon dioxide supply line by means of compressed air. Both pump and refrigeration compressor are controlled by electrodes, and the output of the pump is regulated to be slightly in excess of the filling machine requirements. This results in the level in the reservoir gradually rising until it covers an electrode which, by reason of excitation of an electrical circuit, will stop the pump. As the level falls the uncovering of another electrode will cause the pump to start again. There is an electrical interlock with the compressor, which ensures that the compressor will not start before the pump starts.

When the "Carbo Cooler" is operating the pump supplies warm water to a header tank, where it enters a distribution trough and flows in a thin film over stainless steel cooling plates. During the process the water is cooled to 34 deg. Fah., the cooling being carried out under pressure in carbon dioxide, which ensures that the product is carbonated and that there is no air present to be absorbed. A reservoir at the bottom of the carbonating tank provides a good rest for the carbonated beverage prior to bottling, and an anti-swirl baffle ensures a non-turbulent flow to the bottling machine.

Among the equipment items exhibited was a "Kwikleen" pump, by Mono Pumps, Ltd., Sekforde Street, London, E.C.1, which has been designed for hygienic use and ease of dismantling. The bearings are isolated from the pump and all the metallic surfaces are of polished stainless steel. It is self-priming up to 25ft suction lift and runs at speeds up to 1450 r.p.m. for capacities ranging to 3000 gallons per hour: the maximum pressure is 30 lb per square inch. The pump can be used for vacuum extraction duties and the consistent rate of discharge makes it suitable for high-temperature short-time processing. The Alfa-Laval Company, Ltd., Great West Road, Brentford, Middlesex, exhibited a high-capacity hermetic beer clarifier, able to handle 4400 gallons per hour, and the hermetic design prevents oxidation and losses of carbonic acid. There is a large sludge space of 3·6 gallons capacity and, as there is no filter, pulp losses associated with the filtering process are practically eliminated. Also shown was a self-opening separator for the clarification of liquids containing comparatively high percentages of solids and the automatic, intermittent discharge of solids at full bowl speed. The unit cleans in fifty to thirty seconds and so increases effective working time; during sludge discharge the disc stack is also cleaned so that the clarifier can be run for weeks without being disassembled for bowl cleaning. A paring disc discharges the separated liquid under pressure and seals off the outside air while preventing gases such as carbon dioxide from escaping. The sludge discharge mechanism operates regardless of evaporation or leakage of water in the hydraulic system; the correct water level is maintained by a gravity and paring device, which acts as a centripetal pump. An automatic timing device triggers the sludge discharge mechanism at regular intervals, depending on the sludge content of the feed.

Endless Chain Tub Creeper System

PARTICULARS have been received from the National Coal Board of a means of installing endless chain tub creeper systems without the considerable excavation usually necessary to accommodate the return flight of the chain. This system has been devised by Mr. J. Birch, divisional method study engineer in the North Western Division, and a prototype at Chanters Colliery has proved successful. In this equipment there is used a special roller chain which has been designed for the purpose by the Renold Chain Company. This chain can be flexed in a vertical direction as well as horizontally, and it is fitted with coned bearing pins for connecting the links together, the pins being thickest at the middle and tapering towards the end. The form of construction allows the chain to operate under a change of direction on a radius of 8ft to the vertical and as low as 18in to the horizontal.

For an installation using the new chain pits only have to be sunk at either end of the length of track to be served for the accommodation of the drives and chain wheels beneath the level of the track. At the drive end the chain wheel is driven by a suitable electric motor through reduction gears, the wheel at the other end of the system being mounted in guides incorporating tension adjustment for the creeper chain. This arrangement allows the reverse for the return direction of the chain to be effected in the horizontal plane, so that the return flight can be accommodated alongside the driving chain instead of beneath it. A further development now under consideration is to use the return section of the chain for controlling tubs on the opposite track.

Hydraulic Gear Motors

A RANGE of hydraulic motors has now been introduced by Dowty Hydraulic Units, Ltd., Ashchurch, Glos. The motors are basically similar to the company's gear pumps and incorporate the same system of pressure balancing the gears; the principle of the pumps was illustrated and described on page vii of the supplement to our issue of September 2, 1955. Output speeds vary between 300 and 3000 r.p.m., and powers up to 30 h.p.; the maximum pressure is 1750 lb per square inch on the large motors and increases to 2500 lb per square inch on the small. Most hydraulic fluids are claimed to be suitable, viscosities less than S.A.E. 90 and temperatures below 60 deg. Cent. being specified. Flange or foot mountings are available and pipe connections can be either straight and male or elbow and female in various sizes.

Technical Services Laboratory for Oil Fuels and Lubricants

The Mobil Oil Company, Ltd., has built at Coryton a technical services laboratory to co-ordinate the work concerned with product development and quality control and to provide a technical service to distributors and manufacturers.

TO enable laboratory work to be more closely co-ordinated and to provide for its expansion, the Mobil Oil Company, Ltd., recently completed a technical services laboratory at its Coryton refinery. The building has been specially designed to carry out the work covering product development, quality control and technical service to marketing organisations, distributors and manufacturers. It is not intended that any fundamental research should be undertaken and the equipment is that required to perform practical tests and experiments necessary for the performance of the three main functions already noted.

However, the activities of the laboratory will necessarily include the adaptation, reformulation and modification of both new and existing products to meet market changes and include new basic materials. New formulations will be subjected to performance evaluation tests as part of the work of the laboratory and undergo field trials before being made available commercially.

The technical services department, of which the laboratory forms part, prepares manufacturing specifications for the refinery and the works at Birkenhead and Wandsworth. Laboratories at the refinery and works are responsible for the specifications being met, but samples of all products, from distribution centres, storage terminals and service stations, are constantly forwarded for testing to ensure that quality is maintained up to the point of consumption. Part of the services provided by the laboratory is concerned with the solution of field problems, while approximately 200 samples per week are received for routine testing from shops, industrial plants and automotive sources, both from this country and abroad. Technical service is also available for Coryton refinery and is mainly connected with the assessment of the effect of process variables on product quality, for which purpose small-scale plant is available. Another aspect of the work carried out in the laboratory is the development of analytical techniques to reduce the time required for manufacturing control testing.

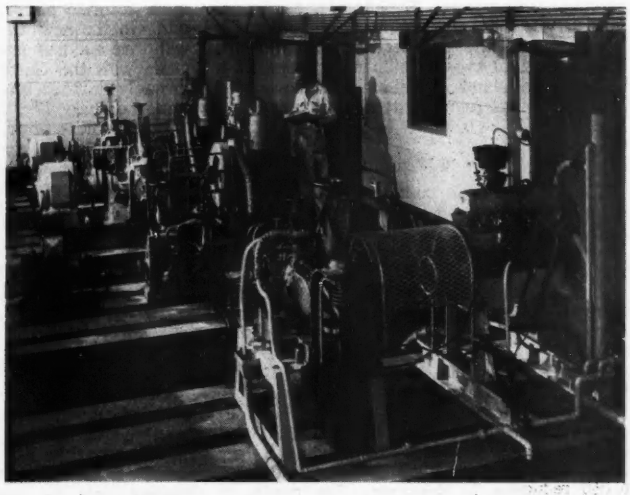
A general view of the building, which is constructed in "U" form and is capable of being extended, is given in our illustration, and has a floor area of 25,000 square feet. The laboratory is built on a 10ft grid of Franki piles and is of reinforced concrete framed construction with columns and beams at 10ft centres. Floor and roof slabs are of concrete and are designed, with certain exceptions, to take a loading of 100 lb per square foot. Of particular interest are the engine test beds, of which there are seven, consisting of blocks of mass concrete supported on spring suspension units to reduce noise levels and eradicate the transmission of vibration. There is one engine bay, which is sound-proofed to eliminate extraneous noise. The concrete frame of the building is faced with silicone-treated precast concrete units, and the end walls are in facing brick, while for insulation purposes there is an inner cavity and a lining of cellular blocks. On the flat roof a three-layer, built-up felt roofing is laid on foamed slag insulation.

Power, water, steam and gas are piped from the refinery and fed to the individual laboratories through a duct beneath the ground floor corridor. For heating the building there is a thermostatically controlled low-pressure hot water system, pump circulated, the water being heated in calorifiers by exhaust steam supplied at 20 lb per square inch from the refinery. Water at 140 deg. Fah. is used for domestic purposes and at 180 deg. Fah. for the heating system. Modular perimeter heaters are fitted in the entrance hall, offices and laboratories, and high-level unit heaters in the workshops and engine bay. Warmed fresh air is supplied to the laboratories through ducting, from two fan chambers, each having a centrifugal fan, filter and heater. Extractors are fitted to provide four changes of air per hour, or more if required, in most laboratories and in the engine test bay exhaust fans having flameproof motors provide for forty changes of air per hour. The architect for the building was Mr. S. Greenwood and the contractors John Laing and Sons, Ltd.

Last week we paid a visit to the new building and were able to briefly inspect the equipment and see something of the work. In one room standard inspection of petroleum products other than fuels is carried out on some 11,000 samples per annum, and in another similar tests are applied to fuels, while in an adjoining laboratory standard engine ratings of gasolines and diesel fuel are established. Improved chemical methods of test to assist laboratory operations are being developed and proved, and the application of modern instruments to testing is being studied. Another aspect of the work is the investigation into the possibilities of improving the efficiency of refinery processes, mainly concerned with lubricating oils, and small-scale equipment is used for furfural extraction, solvent dewaxing and clay percolation experiments. Reformulation of existing grades and the development of new greases, together with sample testing, forms part of the work of the laboratory shown in our illustration, and another section is responsible for the performance testing of fuels and lubricants.

In addition to trials on the engine test beds, as seen in our illustration, there is also road testing of fuels and lubricants. The fuels section, which co-operates closely with the engine and road testing work, is concerned with the development of improved fuels and quality control and investigates such problems as anti-icing characteristics and carbon forming tendencies. Another section performs similar work with regard to automotive, industrial and marine lubricating oils, while the grease and allied products laboratory carries out experiments relating to the development of a wide range of metal processing oils. A recent addition to the scope of the work performed by the laboratories is the testing of fuels and of burning equipment, in conjunction with field investigations, for domestic and industrial heating systems.

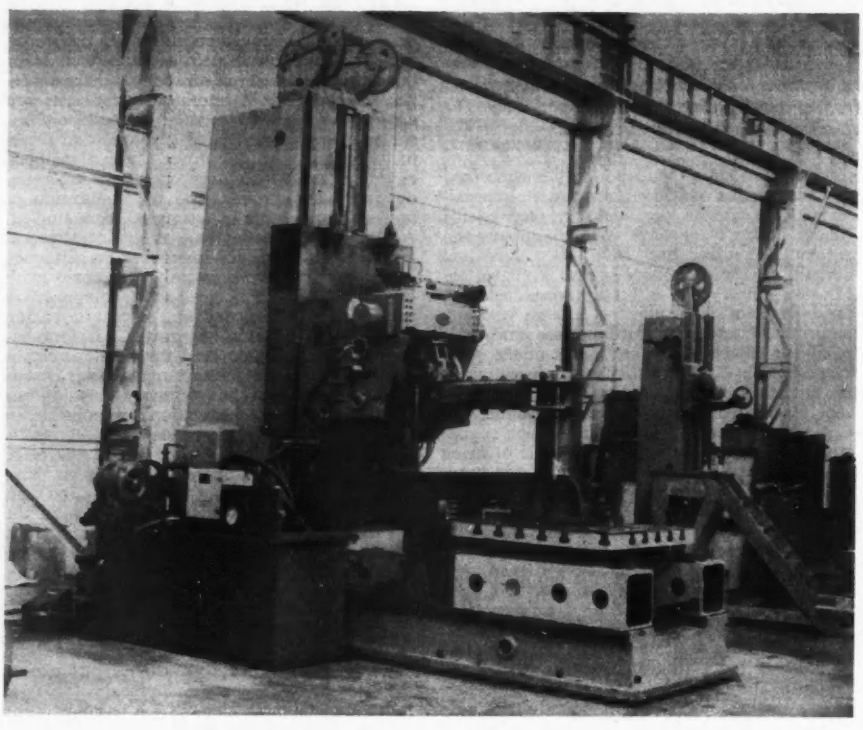
The grease laboratory at Coryton



Engine bay for performance testing of fuels and lubricants

Marine Propulsion Research

THE Parsons and Marine Engineering Turbine Research and Development Association has now issued its Progress Report for 1956. The Council paid particular attention to methods of financing research, and opened the question of proportioning the revenue levy among member firms ; some firms had found the terms for associate membership prohibitively severe, and they also were to be reconsidered. A licence agreement was concluded with a firm in Holland. Pametrada decided to join the Admiralty-Vickers Gearing Research Association ; it was found that there was no requirement by the Admiralty for full-scale trials after YEAD-1. A large new boiler was ordered from Babcock and Wilcox for delivery by early 1959 in order to test merchant ship machinery up to 30,000 h.p. The Association is to offer graduate apprenticeships lasting two years ; approval for this proposal has been received from the Ministry of Labour and National Service and from the Institution of Mechanical Engineers. The library and information service has now commenced to classify reports under the universal decimal system ; it is stated that two-way traffic in documents with other libraries and information sources exists, 516 borrowings and twenty-eight loans being recorded.



Testing in progress on the prototype profile-generating grinding head for a 30/90in gear grinding machine. The head has run at up to 354 single strokes per minute

Steam Turbines

The YEAD-1 trials continued and a number of reports were issued. The double-casing h.p. turbine of Pametrada design built by Hawthorn Leslie (Engineers), Ltd., was returned after modification by the builders and found to have an internal efficiency approximately 4 per cent better. It was inferred that the design of the first-stage nozzles for a certain degree of reaction rendered the Curtis wheel sensitive to axial clearance, and in fact a reduction of 0·017in showed about 1 per cent improvement. The turbine was accordingly further modified to allow the axial attitude of the rotor to be adjusted on load down to a clearance of 0·020in ; 1¼ per cent improvement in efficiency was found for a 0·060 reduction in clearance. The results of investigations on this design are regarded as establishing the necessity for full-scale trials on merchant ship machinery. The design staff attended twenty-one acceptance trials, including those of "Empress of Britain," the first Pametrada installation with reheat. The "Caltex Rotterdam," burning 0·505–0·510 lb per shaft horsepower hour at steam conditions of 600 lb per square inch 940 deg. Fah., is regarded as particularly successful. The mechanical design of the double casing h.p. turbine has, according to the report, been faultless. These conditions, with two feed heaters to 240 deg. Fah., steam-air heaters, and back-pressure turbo-generators, has been recommended for a number of inquiries. Five cases of defective machinery were investigated ; at least one, steam leakage from ahead to astern turbine through the drains, was due merely to drawing-office default.

The rig for the high-temperature turbine, "Pamela," which the previous year was rebladed (see page 60, July 13, 1956), was rebuilt to allow more accurate performance tests to be carried out. In the new arrangement the test turbine will drive a dynamometer ; the first tests will be made with the Curtis wheel turbine that was formerly the steam brake for "Pamela" (see illustration on page 17, January 7, 1955).

Development work on dropwise condensation on the large condenser has now been abandoned, and a small condenser is now to be built in which it will be possible to photograph condensation on glass-walled tubes. The work on air turbines and tunnels continued ; on the single-stage air turbine mechanical losses appeared high compared to the powers developed, so that a Metastream coupling was substituted for a fine-tooth coupling and an optical torquemeter supplied by Torquemeters, Ltd., included.

Gas Turbines

The 3500 s.h.p. marine gas turbine has been reassembled with the l.p. power turbine excluded from the cycle (both compressors, it will be recalled, are driven by the h.p. turbine). Once the newly bladed compressors have undergone proving trials, the engine will be used for long endurance runs on the Admiralty reference residual fuel oils "Mothball" and "Vanilla."

Three design inquiries for gas turbine plant were received during the year. Two were for reversing turbines of 4000 s.h.p. and 1000 s.h.p. for use with free-piston gas generators ; the moderate gas temperatures allowed conventional steam turbine practice to be followed, the ahead blading having five full-admission impulse stages and the astern a two-row Curtis wheel motoring at atmospheric pressure. The third was for a 3000 s.h.p. gas turbine with fluid reversing transmission. The proposed design is straight compounded with reheat before an i.p. power turbine. The turbines are of disc and diaphragm construction with no lengthwise joint in the casing (see page 507, October 7, 1955), and have a maximum temperature of 1250 deg. Fah. The estimated fuel consumption is less than 0·5 lb per shaft horsepower hour.

Construction of the single-stage high-temperature gas turbine is proceeding, the first rotor having withstood a hydraulic test pressure of 3250 lb per square inch. Thermocouples have been fitted to the blades and the face of the rotor. Removal of the rotor for inspection is a very lengthy operation because of the need to split the casing and on account of the low accessibility of the oil, water, and air connections. A new design has been evolved to enable the rotor to be withdrawn axially ; water-lubricated bearings are used, thereby eliminating the need for spring-loaded carbon water/oil seals through which it would be difficult to thread the shaft. The rotor is supported in an unsplit gunmetal sleeve, the cooling air and water supplies and drains being provided by holes drilled in the sleeve wall ; accessibility of the connections is greatly improved. Water flows from one half of the rotor to the other across the blade roots, cooling both the disc rim and the thimble tubes (the blades themselves are convectively cooled by sodium-potassium alloy, as formerly).

Apart from construction of this 2200 deg. Fah. turbine, no work was done on blade cooling. Investigation of the "I.C." (silicon carbide) material of the Morgan Crucible Company continued, and one grade suffered only slight distortion in seventy hours under 5000 lb per square inch stress at 2200 deg. Fah. Corrosion and fouling tests at this temperature have continued with "Vanilla" fuel.

A free diaphragm joint for gas turbine ducting, allowing both flexure and torsional movement, proved under test to be restricted in its flexural movement. Since the incorporation of three universal joints can be shown to give kinematic freedom to any duct, a new design of such a joint including toroidal flexible elements has been designed; it will be extensively strain-gauged and tested to assess flexibility and fatigue life.

The test rig for development of heat exchangers has completed two 500-hour runs fired with "Vanilla," kaolin sea water and "Teepol" being added to the fuel in the first case and the detergent being omitted in the second. Rubber O-rings were found to provide a seal passing 2 per cent or less of the mass flow.

Other Components

A design of boiler with pressurised combustion chamber has been evolved which is hoped to be suitable for low-grade residual oils, having easy access and widely spaced tubes. A water separator suitable for fitting between a boiler drum and a superheater is also to be developed.

Much work is in hand on gearing, limitations on the ability of the gear cutters to improve surface finish and accuracy having allowed only moderate increases in pitch line speeds and loads. The prototype profile-generating grinding head for the 30/90in gear grinding machine which Craven Brothers (Manchester), Ltd., is building under Admiralty-Pametrada patents was mounted on a temporary column and provided with a rotary table to take the test gear (see illustration). The hydraulic system proved capable of maintaining speeds up to 354 single strokes per minute for several hours, and over 750,000 strokes the grinding results were very promising.

A second set of gears were subjected to full-scale trials, these being of nickel-chromium-molybdenum steels and representing the hardest suitable combination which it is possible to hob

and shave satisfactorily. A second power-circulation rig is to be used to speed the testing of several sets of gears with 6/10in pitch, 16 deg. pressure angle teeth.

Another large number of test gears are to be run on the 10in centres high-speed test rig : already a set of En. 27 gears of the tooth form above-mentioned have completed a 200-hour run at a load equivalent to 300K without any detrimental effect due to the high speed of 436ft per second.

A single-tooth test machine has been used to determine the deflection characteristics of the above-mentioned tooth on a rack. The effect of buttressing has been shown, and the results have been analysed to give the deflections of a helical tooth.

A full-scale test rig for the " Auris " hydraulic reversing transmission has now been built on the erstwhile gearbox of the 3500 h.p. gas turbine. Many points concerning manufacture, installation, operation and control were settled with the Shell Petroleum Company and Cammell Laird and Co., Ltd.

Another application of friction clutches examined was an automatic clutch for cruising turbine operation.

Water and other lubricants have been investigated in applications other than the high-temperature gas turbine : a 6in journal was tested on steam and on high-pressure water, and a design for steam lubrication, including vibration damping, was built. Bearings with Mintex " M.6 " and " Tufnol " pads have been made for fitting in the A-brackets of H.M.S. " Cumberland," remarkably low wear having been found in tests using water with a very heavy suspension of sand. The new design has pads covering a considerably greater arc than the staves presently used.

B.B.C. Ultra-High-Frequency Transmissions

THE British Broadcasting Corporation proposes soon to begin a series of test transmissions on 654·25 Mc/s to collect data relating to propagation in the u.h.f. bands (bands IV and V), which were allocated to television at the International Radio Conference at Atlantic City, 1947, but are not so far used for this purpose.

After preliminary laboratory work, the B.B.C. embarked on its first series of u.h.f. propagation measurements in 1955. They were aimed at the investigation of propagation on frequencies between 470 and 960 Mc/s, over distances representing a normal service area, and over longer distances to obtain information for the evaluation of co-channel interference. The initial tests were for the latter purpose and used transmitters, modulated by square waves, manufactured for the B.B.C. by Mullard Electronic Products, Ltd. The transmitters were installed at various television transmitting stations, the aerials being erected high up on the television masts. Regular field-strength measurements were made over long periods at various locations, some as far away as the Shetland Islands. These transmissions are still in progress.

The long-distance tests were followed in 1956 by a series of tests to determine propagation conditions within a typical service area using a transmitter at the Crystal Palace, working into a Yagi aerial and radiating a peak power of 1kW over a fairly narrow beam when modulated with square waves ; pulse modulation was also used for some of the tests. The bearing of the aerial, which was at a height of 440ft, was changed from time to time so that field strengths could be measured over the whole circle from Crystal Palace. These measurements have been completed and the resulting information concerning field-strength contours and an assessment of shadow and echo effects are now being studied.

However, the information collected in this way was insufficient to determine fully the suitability or otherwise of bands IV and V for television broadcasting, and, at the request of the Television Advisory Committee, the B.B.C. decided earlier this year to start a more ambitious series of experiments using a high-power transmitter and radiating full television signals, initially on 405 lines and later on 625 lines (C.C.I.R. standards). These tests have been planned by the B.B.C. in co-operation with the Television Advisory Committee and the radio industry.

For this work the B.B.C. has installed at the Crystal Palace a 10kW peak-white u.h.f. vision transmitter and a 2½kW carrier power sound transmitter manufactured by E.M.I. Electronics, Ltd., the vision frequency being 654·25 Mc/s. The equipment is low-power modulated on both sound and vision channels and employs " Eimac 3K50000LF " klystrons in both audio and video final stages. These klystrons use three external cavity resonators and operate as linear amplifiers with a power gain of approximately 100. They are driven by a modulated amplifier stage operating with a cathode modulated circuit. The output of the transmitters is combined in a filter-bridge circuit built in rectangular section waveguide. The combined output is then taken to the aerial by an elliptical waveguide 12in by 6in. The elliptical waveguide is made of 99·5 per cent aluminium in 12ft lengths. At the top of the television mast the waveguide is transformed into a 5in concentric feeder to take power to the four driving points of the helical aerial, the pole supporting the aerial being arranged to form the outer of the concentric feeder.

The helical aerial is made of ¼in diameter copper rod and comprises four bays, mounted one above the other on the same vertical axis, each having a linear height of five wavelengths. Each bay is fed at the centre, the helix being wound from the centre point of the bay in opposing directions to cancel the vertical component of radiation. In the four bays there is a total of forty-eight turns, each turn being approximately two wavelengths long. The aerial is mounted at the summit of the Crystal Palace tower, the top of the 6½in diameter pole supporting the aerial being 707ft above the ground, while the centre line of the aerial is 691ft above the ground. The aerial has a power gain of 20 and, after allowing for losses in the feeder and waveguide system, the effective radiated power of the vision signal is of the order of 125kW peak-white in the horizontal plane. Provision is made for de-icing the aerial by electrical heating.

Starting early this month the transmitter will be in use for several hours a day radiating pictures on the 405-line standard. The pictures will be the same as those radiated by the band-I transmitter installed in the same building. Later on, the pictures on 625 lines will be produced at Lime Grove from flying spot teleciné equipment supplied by Cinema-Television, Ltd., and sent over a specially equipped co-axial cable to the Crystal Palace.

The tests on 405 lines will continue until about March, 1958, when there will be an interval for the transmitter to be adjusted to radiate on 625 lines. A second series of tests will then begin and will continue for a period not yet decided. For these latter tests, the programme will usually be different from that being radiated by the band-I transmitter, but at certain times duplicate copies of films scanned on the two systems will be radiated by the two transmitters simultaneously.

The B.B.C., the radio industry, the Post Office, the D.S.I.R., and the I.T.A. are organising comprehensive studies of the received pictures. The receivers themselves will be of various kinds, representative both of designs that might become available at economic prices to the public and also of other designs not at present suitable for public sale. In addition to reception at fixed points, vehicles are being equipped with receivers and test equipment. The B.B.C. hopes that the information which will be gained from these tests will throw light on the problems which would be encountered were it decided to provide television services in the u.h.f. bands, and the effects of a change of U.K. television standards for those bands to conform with those used on the Continent. But the B.B.C. does not intend to make any change in the 405-line standard used for B.B.C. television in band I.

Diesel-Electric Shunting Locomotive

THE photograph reproduced on this page shows the first of three 660 h.p. B_0B_0 diesel-electric shunting locomotives being built for the Steel Company of Wales, Ltd., by Brush Traction, Ltd. This 90-ton locomotive is designed for a maximum tractive effort of 50,000 lb, a continuous tractive effort of 19,750 lb at 7 m.p.h., and a one-hour effort of 24,400 lb at 6·5 m.p.h.

Power is supplied by a six-cylinder, pressure-charged, four-stroke Mirrlees " JS6 " engine, developing 660 b.h.p. at 875 r.p.m. on the one-hour rating and 600 b.h.p. at 850 r.p.m. on the twelve-hour rating. The engine is coupled to a Brush d.c. main generator with a continuous output of 322kW. This " three-field " generator has separately excited and self-excited shunt windings and a differential series winding, and an additional winding is provided for engine starting purposes. It supplies current to four axle-hung, nose-suspended traction motors, which drive the axles through double reduction spur gearing.

The locomotive has a rigid underframe of welded rolled steel sections and plate. The underframe is supported on the fabricated bogies through flat pivots carried on fixed bolsters. The bogies have manganese steel lined horn blocks and are fitted with roller bearing axleboxes on which the bogie frames are supported through coil springs and drop equaliser beams. Two double-piston brake cylinders on each bogie actuate clasp brakes on all wheels, and a hand gear operates on two wheels of one bogie only. An electro-pneumatic sanding gear is arranged to sand the rails in each direction of running.

The superstructure, which is built up of rolled steel sections and plate, is divided into compartments containing the radiator, engine, generator and driver's cab at the rear. A compartment between the deckplate and the floor of the cab houses the main fuel tanks of 350 gallons capacity. The driving controls are duplicated on each side of the cab, which has large windows to give adequate vision in both directions of travel. Large doors in the sides and roof of the superstructure give adequate access to all parts.

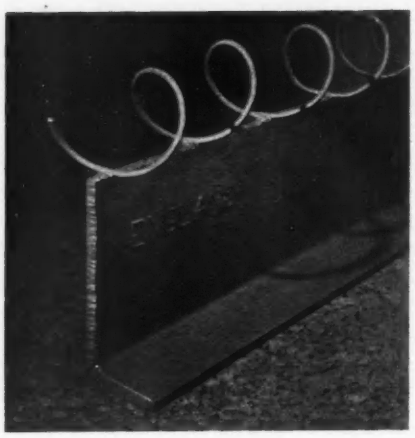
660 h.p. diesel-electric shunting locomotive with a maximum tractive effort of 50,000 lb

Composite Steel and Concrete Construction

A NEW method of employing structural steel and reinforced concrete in a composite manner, with the aim of exploiting the strength in tension of the structural steel and the strength in compression of the concrete, was demonstrated last week to various authorities and to the Press. The method has been developed jointly by the consulting engineers, Messrs. Jenkins and Potter, and by Dr. Plowman, of King's College, London, and is already being used by one firm of suppliers, Mackey Bowley and Co., Ltd., 21, Caledonian Road, London, N.1.

The basic consideration from which the new method evolved, was of a normal rolled steel joist carrying a concrete floor slab. With such a combination, full usage of the material in the compression zone of the joist is not obtained. By cutting the joist in half, and eliminating the half above the neutral axis, the same structural strength would be obtainable provided the concrete above the neutral axis could be made to behave monolithically with the structural steel below it. This has, in fact, been achieved by welding a spiral of reinforcing steel to the top of the cut joist, in the manner shown in the illustration. The floor slab is then cast with its soffit at approximately the level of the top of the cut web of the structural steel. Construction of the slab, and also encasing concrete for the joist, follow normal practice. Thus, a 50 per cent saving in weight of structural steel in the beams of a floor system can be achieved without sacrifice of strength.

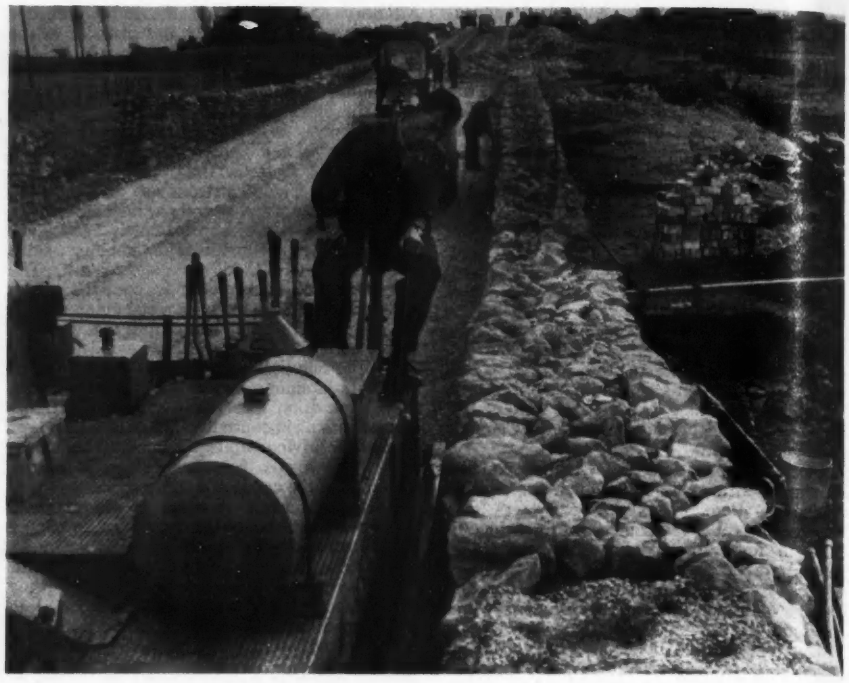
Design of the composite system is straightforward, and design tables are being prepared to cover the range of floor spans, loading and beam spacings which the method will cover most advantageously. The structural steel itself need not necessarily be a rolled steel joist cut in half,



Rolled steel joist cut at mid-depth of web, with spiral reinforcement welded to it

and plates and angles or channels can be adapted. Then design computation (given the structural steel size) establishes the pitch of the spiral reinforcement. Extra spirals may be welded to each end of the beam where shear is greatest.

The development of this method of construction has involved a considerable amount of testing, including full-scale tests of sections of floor slab. Load factors at failure have exceeded 2, and a value of about 2·5 was recorded at the test demonstration. A point of special interest in the tests was the mode of failure, namely, yielding of the structural steel in the tension zone of the composite structure. Failure by separation between the steel and the concrete has not been encountered, and the composite structure has generally verified design assumptions by its behaviour in the tests. It is of interest to note that this composite method, which gives steel economy only for the beams of a building, is in some ways complementary to the late Dr. Faber's recent work on composite steel and concrete columns. By combining the two, a multi-storey building making a more rational combination of structural steel and concrete might thus be obtained.



Dry stone filling material being placed in 6in layers by a paver-finisher machine, on the A.20 road. The first day's work is shown in progress: eventually the fill will reach a maximum height of 7ft and extend back almost to the bridge in the background. The road is open to traffic

Regrading a Trunk Road

BETWEEN Maidstone and Ashford, near the village of Charing, the London to Dover road, A.20, passes over a railway bridge. On each side of the bridge, regrading has been necessary to give acceptable sight-lines for traffic, and generally to improve the alignment and traffic flow in the neighbourhood of the bridge. The "valleys" in the road on each side of the hump of the bridge have thus been filled in, and the methods used on each side of the bridge provide an interesting contrast. The road has been kept open to traffic throughout the work.

On the Dover side of the bridge, stone of 9in size was hand-pitched in 18in layers, and blinded with small stone. The horizontal curvature was also improved, but it is primarily the regrading which is relevant here. Depth and quantities were of the same order as the work to be described on the other side of the bridge, and the job was done in about ten weeks.

On the London side of the bridge, regrading is based on the use of a Blaw-Knox paver-finisher,* which is being used to lay and compact dry stone in 6in layers. Retaining walls—built of borderstone and a concrete core—were first built along each side of the road. They can be seen in the illustration. Then the stone fill was placed, in 6in layers, and in three "lanes" to cover the width of the road. The stone is 2½in crusher-run Kentish ragstone, with a high proportion of fines added at the quarry. Sieve tests were carried out with this stone to ascertain that the grading thus obtained would be reasonably constant, and satisfactory for consolidation of the fill.

The length of road thus regraded on the London side of the bridge is about 300 yards, and the maximum depth of fill is about 7ft. The total quantity of stone is about 3500 tons, 2500 tons of which was placed during the course of last week. The paver-finisher worked at a rate equivalent to about 200 tons per hour, whilst the supply of stone was maintained, but as is expected with this class of work, progress was limited by the rate of delivery of stone to the site. The illustration shows a comparatively short layer of fill in the lower part of the work; the length of each run of the machine extended as the filling progressed. Two 10-ton rollers worked behind the paver-finisher, consolidating each layer of newly-placed material. One of the three lanes was always open to traffic. The completed fill will be topped with a base course of tarmacadam, which will be left for a period before the wearing surface is constructed.

We understand that this method of regrading is considered to have shown itself to be advantageous, in speed and cost, when compared with the hand-pitching of the earlier work. Regrading of the A.20 road has been carried out by the roads department of Kent County Council, under the direction of Mr. E. W. H. Vallis, M.I.Mun.E., the county surveyor.

* This machine was described in THE ENGINEER of January 27, 1956.

South Wales Institute of Engineers

THE South Wales Institute of Engineers has now completed the first hundred years of its existence. The decision to form the Institute was taken at a meeting held at Merthyr on September 30, 1857. That meeting, we reported at the time, was attended "by engineers and mineral proprietors interested in the railways and works of South Wales." At a further meeting, held on October 29, 1857, William Menelaus was elected president and a constitution was approved. The object of the Institute was then defined as being "to devote itself to the encouragement and advancement of engineering science and practice; it being established to facilitate the exchange of information and ideas amongst its members, and to place on record the results of experience elicited in discussion."

To mark the centenary, an account of the Institute's history has just been published. It includes interesting references to the varied activities in which the Institute has engaged during its first century, shows how the membership has grown from 129 to a total (at the end of June last) of 1400, and details the events which led to the Institute acquiring its present premises in Park Place, Cardiff.

In addition, there are, of course, references to the men—presidents, vice-presidents and secretaries—who have contributed much to the success of the Institute's work. A particularly interesting part of the history is the selection of biographical sketches of some of the engineers who have occupied the presidential chair. Then, there is an excerpt from the inaugural address of the first president. In that address he expressed concern at the wastefulness of the processes in use in iron works and coal mines, saying that on all sides there was inefficiency. Menelaus urged also that as education refined men's tastes, they aspired to something beyond manual drudgery.

If education was not to be the means of lightening toil and lessening the hours of work, he said, small good would it do! Hence, Menelaus urged, machines and tools must be invented and brought into use to ensure that labour was used to the best advantage.

The South Wales Institute of Engineers, which was incorporated by Royal Charter in 1881, became federated to the Institution of Mining Engineers in 1952, though it has retained its title and autonomy. Last Tuesday, the centenary was formally celebrated by a special meeting at which the William Menelaus Memorial Lecture, entitled "The Development of Britain's Physical and Geographical Advantages" was delivered by Sir Charles Goodeve.

Crankshaft Grinding Machines

A NEW heavy duty universal crankshaft grinding machine developed by the Newall Engineering Company, Ltd., of Peterborough, is designed for the regrinding or grinding on a production basis of both main journals and crankpins. It has a 28in swing, takes work from 36in to 84in between the workhead and tailstock spindle flanges, and incorporates a fully automatic grinding cycle.

On this machine, to be seen in the accompanying illustration, both of the workheads are driven from a 5 h.p., 960 r.p.m., motor by a common shaft, an arrangement which ensures accurate radial positioning of crankpins. A seven-speed gearbox, providing work speeds of 35, 41, 47, 52, 58, 64 and 72 r.p.m., covers all normal requirements for crankshaft grinding. The right-hand workhead has handwheel control which provides for lateral adjustment of the centre to facilitate loading during the main line journal grinding operation. A heavy duty wheelhead mounting a 42in diameter wheel has a 6in rapid approach stroke and four automatic variable rates of infeed are provided, one for face grinding and three for diameter grinding, the latter giving in effect a diminishing feed. A micro-adjusted diamond dresser may be clamped in either workhead for dressing the wheel to the correct width. A table-mounted radius dressing attachment is also available for use when journal grinding, and a dresser-bar-mounted radius attachment is supplied for use when crankpin grinding.

Table traverse is hydraulically operated at steplessly variable rates between approximately 3in and 160in per minute under a single joystick control. Automatic positioning of bearing or pin with respect to the grinding wheel is effected by a spacer bar and hydraulic plunger located on the front of the machine, separate spacer bars for crankpin and journal grinding being supplied as standard equipment. Both of the throwblocks are easily detachable from the work spindle flanges to enable rapid changing over of the machine from crankpin to journal grinding, and the left-hand block is designed to accommodate a dividing plate suitable for the type of crankshaft to be ground.

A Newall electro-sizing gauge is fitted to determine finish diameter correctly and control the automatic cycle of the wheelhead, whilst wheelhead approach and retraction may be controlled manually by operating the isolator switches provided.

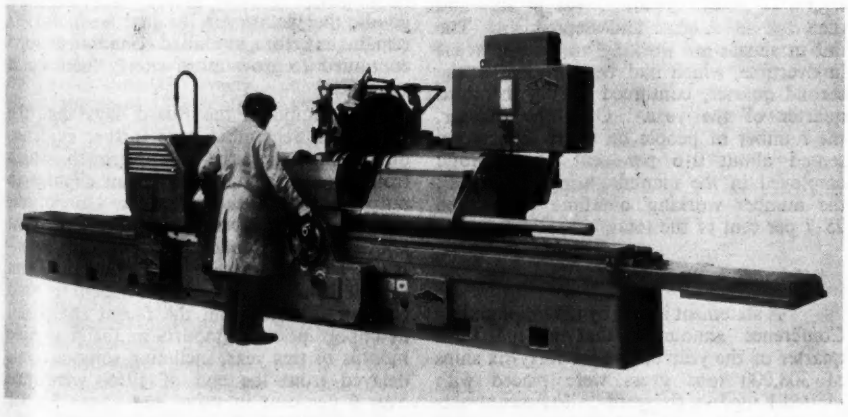
The automatic grinding cycle is identical for both pins and journals. In its sequence the machine table is positioned by a hydraulically operated plunger locating in a spacer bar. Forward movement of the "joystick" control lever starts the workhead and approach of the wheelhead. The wheelhead has a quick approach to a predetermined position when the infeed rate slows and the crank web faces are ground. This accomplished, the infeed rate is again reduced, coolant commences to flow and the wheel begins to grind the diameter. The electro-sizing gauge is applied to the workpiece and feed continues until the workpiece is between plus 0·005in and 0·01in on the finish diameter when a yet slower or semi-finishing feed is brought into operation. The final infeed rate operates slightly before finish size is reached; the sizing gauge then takes control and withdraws the wheelhead immediately the correct diameter is established.

In addition to the machine described above, the Newall Engineering Company has recently completed the first of a new series of automatic crankpin grinders developed for large-scale production of four or six-cylinder crankshafts. This new machine enables production economy to be achieved as, for grinding four-cylinder shafts, a pair of machines may be employed, one for each pair of in-line crankpins, the cycles of operation being so arranged that one operator controls both grinders.

After loading and clamping the shaft in position on the machine, the start button is pressed to bring the wheelhead forward at rapid approach and to commence rotation of the shaft. Rapid approach is to a distance just clear of faces to be ground, when the wheelhead proceeds to feed at a predetermined rate until faces are finished. A further roughing feed is then automatically applied until a diameter within approximately 0·006in of finish crankpin size is reached; at this point the feed is further retarded. A steady rest then comes into position, slowing its rate of approach in the final stages, to permit a Sigma air sizing gauge to locate smoothly on the pin. Feed continues until a signal, indicated by a light, stops the feed for a dwell period and the grinding operation then ceases on receipt of a further signal which is transmitted when finish diameter is achieved. Automatic rapid withdrawal of the wheelhead and feed then follows; the steady rest and sizing gauge are retracted to their inoperative positions, and work rotation ceases.

On reaching its rearmost position at the end of this cycle, the wheelhead operates a control circuit which indexes the table to a position opposite the pin in line with that already ground. On final location in the spacing bar, the table locking plunger engages a micro-switch to commence repetition of the grinding cycle. After completion of the second crankpin and return of the wheelhead, the table returns automatically to the grinding position for the first pin in readiness for another shaft to be loaded. By use of a single rotary switch the entire automatic cycle of this machine can be disengaged, and a set of control buttons for manual application during setting-up, brought into operation. These controls are for advancing the wheelhead, retracting the wheelhead, and for indexing the table to the requirement of the component to be ground.

The machine is provided with a hydraulically-operated wheelhead-mounted dresser having three diamonds which permit both radii and front face of the wheel to be finish dressed in one operation. When using this dresser, the feed advancing the diamond is applied by push buttons which simultaneously advance the wheelhead to compensate for reduction in wheel size. The controls for the dresser are duplicated at the rear of the machine for use during setting-up and a safety device prevents the diamond carriage being traversed unless the wheel is in the correct position for dressing. Other attachments are provided to be clamped in the throwblocks for initially roughing-out the wheel shape.



Universal crankshaft grinding machine with automatic grinding cycle

Light Commercial Vehicles

THE first Dagenham Ford vehicle to feature full forward control is the chassis for estate cars and vans of 10/12 cwt and 15 cwt capacity introduced to-day. The crew sit above the front wheel boxes, and the power unit, identical with that of the Mk. II "Consul," is set between them. Cooling and combustion air is taken in through a large intake low in the front of the vehicle and ducted to the radiator, which is in front of the engine. A long remote control for the gearbox ends on the left-hand side of the steering column. Behind the power unit there extends a light ladder-style chassis, which allows special bodies to be built, a separate cab to be incorporated, or chassis-windscreen combinations to be exported. Hotchkiss drive is used; the axle, like those of the Mk. I and Mk. II cars, is a pressed steel banjo and, therefore, fully floating.

The front suspension resembles the Ford practice in U.S.A. rather than Europe, employing ball joints on double wishbones; this is because the vehicle, in the delivery van application, was expected to suffer impacts against kerbs, which would impose unfavourable bending stresses on the telescopic member of a MacPherson suspension. Had sliding pillar suspension been used, the crew would have had to be seated even further forward to accommodate the front springs behind them; in this case a bulkhead behind the cab might also have been necessary, while the actual vehicle has only a step down into the body.

The design of the standard steel body presents some points of interest. Since a chassis exists, the shell is not primary structure, and the side skirt panels can be detached to rectify accidental damage. The roof is stiffened along its major dimension by swaging, as are those of the 5 cwt and 7 cwt vans, but in the other plane it is merely damped against vibrations which would be audible. This is achieved by cross members padded with felt; the transversals are screwed to the sides, and provision is made to adjust them when the felt loses its initial compression. The doors, which are hinged, have sliding windows and it is therefore possible for them to be closed in manufacture into a sealed box; moisture running off the windows is carried away by a moulded duct.

Other distinctive details are that the spare wheel is carried completely concealed under the rear of the chassis; it is introduced into its stowage by passing a hook through the wheel centre and engaging it with the retracting linkage. The linkage is then moved up and forward by a screw jack operated by the wheel brace. When the assembly is finally stowed, it is supported by the wheel and not the side walls or tread of the tyre. A mechanically driven speedometer is the main instrument, and uses the "moving arc" presentation; since it is set below the windscreen, it is well away from the normal line of vision of the driver.

The 10/12 cwt and 15 cwt Thames vans will have taxation and laden weights of 2150 lb and 34 cwt and 2175 lb and 37 cwt respectively. The final drive ratios are 4·11 standard, 4·62 and 5·12 optional, and 4·65 standard, 5·12 optional respectively. In addition to the two doors for the crew and the two doors in the back, a door in the centre of the near side is optional. On the eight-seater estate car, which will be in production next year and weigh 2478 lb, a folding step extends below this door when it is opened.

Industrial and Labour Notes

Iron and Steel Tariffs

The sixth session of the Council of Association between the United Kingdom Government and the High Authority of the European Coal and Steel Community was held in Luxembourg last week. At the end of it, it was announced that full agreement had been reached on proposals to be sent to the governments of the six Community countries and the British Government "for a substantial reduction of iron and steel tariffs in the United Kingdom and the Community."

The proposals invite the Government to sign an agreement by which the United Kingdom would reduce its customs duties on a wide range of iron and steel products from the current level of 15 to 33½ per cent *ad valorem* to a level not exceeding 10 per cent, with an appropriate adjustment of the alternative specific rates. On the other side, the member states of the Community will apply rates not exceeding those resulting from the harmonisation of their customs duties at the end of the transitional period. These maximum rates are likely to vary between 3 and 12 per cent *ad valorem*. If any of the signatories wishes to increase its customs duties, there will be prior consultation between them about possible courses of action which would avoid the necessity for increased duties, or, if no agreement is reached, on the extent of the increase in these duties.

An announcement concerning the proposals was made at the end of last week by the Board of Trade. The Board of Trade describes the proposed tariff reductions as "an important step towards the objective of eliminating trade barriers between the United Kingdom and the Community."

Management-Employee Relationship

The Minister of Labour, Mr. Iain Macleod, spoke at a luncheon meeting of the Industrial Co-Partnership Association on Wednesday of last week. In his talk, he emphasised the need for employees to have confidence in the attitude of management towards themselves. That attitude, the Minister said, must be consistent and it must be reflected in all management decisions. Well thought out employment policies, the Minister added, were essential to the building up of real confidence, and in the hope that other firms might be encouraged to follow the example of those who had already taken steps in the matter, he was arranging for a small booklet on the subject to be issued in the near future.

The Minister went on to say that just as firms had different sales and production and financial policies so, of course, they would have different employment policies; but each must be integrated with the other and form part of a whole. Yet, he commented, an employment policy would only build up confidence if it took into account the basic needs of employees both as individuals and as members of their working group, and if administrative procedures were adequate to translate the policy into practice. The desire to establish a "sense of justice" meant that people should have a clear understanding of their rights and their obligations. It was most important, the Minister urged, that employees should know from the beginning where they stood and what was expected of them. The Minister ended his speech by saying that possibly one of the most difficult problems for top management in industry, or indeed anywhere else at the present time, was how to ensure that the policy and attitude of the firm were understood and applied in all day-to-day managerial decisions. Confidence and relationships were impaired when management's policy was not carried out in the local factory or on the shop floor; they suffered equally when matters always had to be referred to a higher level. The answer, Mr. Macleod emphasised, was surely to be found in the much better selection and training of supervisors and managers, and in the development of the habit of frequent discussion and consultation up and down the line of management.

National Joint Advisory Council

The Minister of Labour's National Joint Advisory Council held its quarterly meeting in London on Wednesday of last week. This council, it may be recalled, consists of representatives of the British Employers' Confederation, the Trades Union Congress, and the boards of the nationalised industries. The Chancellor of the Exchequer attended the meeting for the purpose of discussing the implications for industry of the present phase of Government economic policy. An official statement issued after the meeting said that the Chancellor "emphasised the severity of the problem which the country would face if the stability of the pound was not maintained, and the way in which the interests of industry and the public were directly involved in the successful defence of sterling." According to the statement, the Chancellor went on to explain "the general nature and purpose of the measures taken and contemplated, but gave no details of the proposed limitations on various investment programmes."

Among the Council's normal business, there was consideration of the manpower position and of statistics relating to short time and overtime working. A report submitted to the Council showed that the rise of 116,000 in civil employment during the third quarter of this year was largely a seasonal improvement. The fall in unemployment, which had been noticeable in the preceding quarter had continued up to the end of July. Thereafter, unemployment increased seasonally, the September figure of 267,000 being much the same as the June figure. Unfilled vacancies rose in July and then fell in August and September. The fall in short-time working and the increase in overtime, which had been evident in the second quarter, continued during the third quarter of the year. Over the quarter, the number of people on short time represented about 0·6 per cent of the total employed in the manufacturing industries; the number working overtime represented 25·7 per cent of the total.

Shipbuilding Statistics

A statement issued by the Shipbuilding Conference announces that in the third quarter of the year orders for forty-six ships of 308,000 tons gross were placed with United Kingdom shipyards. These contracts brought the total of orders received this year to 207 ships of 1,498,000 tons gross and the total of orders placed in the twelve months ended September 30, 1957, to 350 ships of 2,708,000 tons gross. The order book at September 30 contained contracts for 848 ships of 6,971,000 tons gross, valued at £975 million, of which 20 per cent is for foreign account and 54 per cent are oil tankers.

Manufacturing Industry's Stocks

The Board of Trade has stated that the final estimate of the change in the value of manufacturers' stocks and work in progress during the second quarter of this year shows an increase of about 1½ per cent over the first quarter. This increase was smaller than that evident in the first quarter (4½ per cent) and also smaller than the increases during the second quarters of 1955 and 1956 (2 and 3 per cent respectively).

Overseas Trade

In its latest report on Britain's overseas trade, the Board of Trade says that the figures for both exports and imports in September were the lowest recorded this year. The final figures for September were: exports, £246,300,000; imports, £308,400,000 and re-exports, £9,800,000. The visible trade deficit of £52,300,000 showed a further small improvement in September, but, the Board of Trade comments, it remained close to the average level of the earlier months of the year.

The report goes on to explain that although the lower level of exports in August and September brought the monthly average for the third quarter to 5 per cent below the rate for the first half-year, it was nevertheless 8½ per cent above the third quarter of 1956. But, it is added, shipments in the third quarter last year were somewhat affected by the requisitioning of shipping in the first stage of the Suez crisis, so that "the recent acceleration in the rate of growth may be more apparent than real." For the first nine months of this year, exports show an increase of 7 per cent in value and about 3½ per cent in volume over the same period of 1956. This is less than the increase achieved in 1956, but, as far as value is concerned, still rather bigger than the rise in the two years before that. The attainment of a substantial annual rate of growth, the Board of Trade claims, has thus been extended into a fourth successive year. It is pointed out, however, that in relation to the development of world trade in manufactured goods, the picture for the first half of 1957 remains as before, as United Kingdom exports continued to grow more slowly than world exports.

About imports, the Board says that the figures for September gave further evidence of a slackening in the rate of growth, which from March to July had begun slightly to outpace the growth in exports. In August and September imports were only 4 per cent above the corresponding 1956 figures, compared with an average of 7 per cent from March to July. This improvement is said to have resulted from the recent sharp fall in import prices. Imports in the first nine months of this year, including some arrivals delayed from the end of 1956, were just over 6 per cent in value and about 3½ per cent in volume above those for the comparable period of last year.

Reconstruction of August Thyssen-Hütte

No. I

Before the war, the August Thyssen-Hütte formed the largest unit of the Vereinigte Stahlwerke steel combine, which itself was the second largest steel producer in the world, after the United States Steel Corporation. Its peak production was in 1938, *when the output of crude steel amounted to* 2,400,000 *tons. After the war production equipment was largely dismantled with the principal exception of most of the blast-furnaces. Rebuilding began in* 1950, *and has proceeded rapidly, so that an annual steel production of* 2,400,000 *tons is again within sight. Here we outline the historical background, and describe some aspects of the reconstruction.*

THE history of the August Thyssen-Hütte goes back to 1890, when August Thyssen (1842–1926) bought 215 hectares of land at Bruckhausen, near Hamborn. Thyssen, who, after studying at the Karlsruhe Polytechnicum and at the College of Commerce at Antwerp, had for several years worked in the banking business, had already operated, in partnership, the strip mill Thyssen, Fossoul and Company, in Duisburg (1867–1871). In 1871 he had founded the firm of Thyssen and Company in Müheim (Ruhr), which installed five puddling furnaces, one slab mill and one strip mill, and which from 1880 onwards expanded to include the production of tubes, sheets and sections, open hearth steel, foundry and engineering products. As the first steel producer in Europe he followed the principle of the integrated economy involving the horizontal and vertical expansion of his activities to coal (coal mine Gewerkschaft Deutscher Kaiser, purchased 1888), ore, iron smelting and transport. Eventually, Thyssen controlled some 300 square kilometres of coal fields and concessions, iron mines in Lorraine, Normandy, Morocco and the Caucasus, as well as rolling mills (Dinslaken), gas and waterworks.

The choice of Bruckhausen as the site of Thyssen's steel works was due to the presence of coal in the neighbourhood and the favourable transport situation on the banks of the Rhine. The far-reaching plans which Thyssen had from the beginning are shown by the large area of land which he purchased. Expansion of the works was pursued with great energy and single-mindedness and all profits were ploughed back until 1904.

In 1926, the August Thyssen-Hütte was converted into a limited company and after the founder's death, became the largest single unit of the Vereinigte Stahlwerke combine which was second only to United States Steel. Crude steel production reached a peak in 1938–39 with 2,400,000 tons. After a drop to about 1,500,000 tons in 1941, output rose again to 1,800,000 tons and then declined. Heavy bombing in the last months of the war eventually brought production to a standstill in January, 1945. Although limited activities were resumed after hostilities had ended, the works was later scheduled for dismantling. After preparations had been made to this end in 1947, the dismantling programme was carried out at increasing speed from September, 1948, until it was brought to a halt two days after the signing of the Petersburg Agreement on November 22, 1949, although the removal of items that had already been dismantled continued until December, 1950.

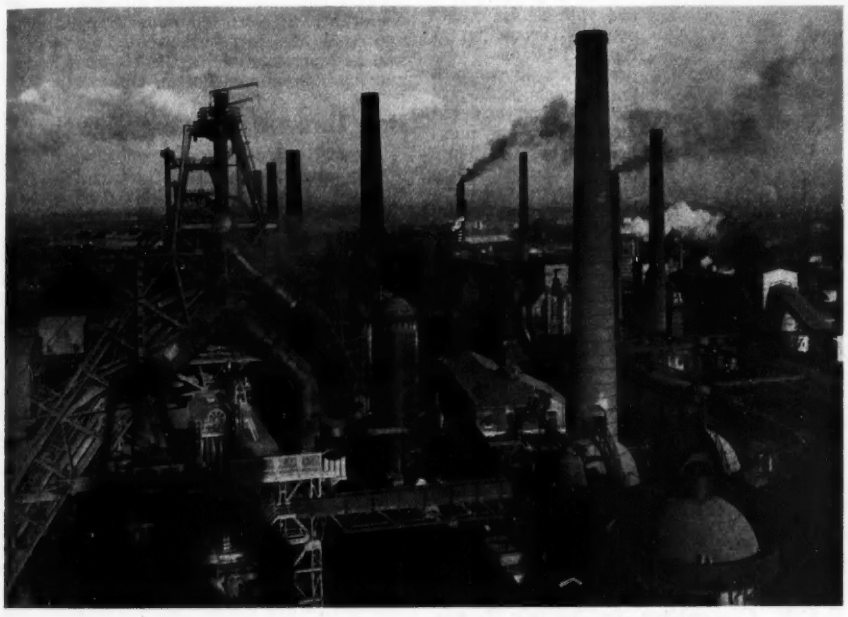


Fig. 1—View from No. 9 blast-furnace in a northerly direction, showing No. 8 blast-furnace and (right) coking plant

Of the 55,000 items totalling 269,230 tons on the original inventory, 116,566 tons of those dismantled before November, 1949, were eventually removed. These are stated to represent a value of DM.215 millions, so that, if bomb damage is included, the works suffered direct losses of about DM.425 million as the result of the war and its aftermath (1955 replacement value).

Following the breaking up of the Vereinigte Stahlwerke, the August Thyssen-Hütte was re-established as the last of the successor organisations on May 2, 1953.

Reconstruction began in the spring of 1950. In May, 1951, the first two blast-furnaces Nos. 7 and 3) began production. Then followed a period of rapid reconstruction with the objective of reaching eventually an annual steel production of 2,400,000 tons.

The effect of dismantling on production capacity may be gauged by reference to Table I,

TABLE I—*Equipment of August Thyssen-Hütte*

	At end of World War II	Dismantled	Autumn, 1957
Annual crude steel capacity, million tons	2·4	—	1·9*
Number of blast-furnaces	8	1	7
Mixers	3	3	4
Basic Bessemer converters	7	7	6
Electric furnaces	7	7	—
Open hearth plant I	6	6	4
Open hearth plant II	6	2	6
Cogging mills	3	3	2
Heavy finishing mills	4	3	1
Medium and finishing mills	4	3	1
Continuous hot strip mill	—	—	1
Cold sheet rolling mill	1	1	1
Coking plant	—	—	5 batteries (345 ovens)

* This figure will rise to 2,400,000 tons when the eighth blast-furnace comes into operation in 1959.

which also lists the principal new equipment.

A certain number of installations were not dismantled, however. These included Hamborn power station, the old steam power station, the generators of the two open-hearth works, the oxygen plant, sintering plant, workshops and Schwelgern harbour. Thus, there remained sufficient which was of value to make reconstruction on the former site worth while. In the rebuilding, plans were based on an investment of DM.300 per year–ton of finished product, which is only about 30 per cent of what a similar steelworks on a virgin site would have cost. The immediate goal of 1,400,000 tons of crude steel per annum was exceeded during 1955–56 when 1,600,000 tons were produced. It is expected to achieve a capacity of 2,400,000 tons this autumn when the second open-hearth plant will be in full production. Actual output will, however, remain below this figure until the eighth blast-furnace is started in 1959, owing to the need of reconditioning each year one of the existing furnaces. The total investment to reach 2,400,000 tons will, it is stated, amount to DM.670 million, plus DM.37,000,000 for a strip galvanising line, various laboratories and offices, and two ocean-going coal-carrying freighters. More recently the splitting up of the larger concerns which the Allies effected after the war has gone into reverse.

Table II shows the structure of the August Thyssen-Hütte interests, which, as the last annual report states, were acquired principally to achieve a more economical division of production.

TABLE II—*Structure of A.T.H. Concern in March,* 1957

Parent company : August Thyssen-Hütte (capital DM.240 millions)

A.T.H. subsidiaries	Location	Business	Capital (DM. millions)	Per cent interest of A.T.H.
Erin Bergbau A.G.	Castrop-Rauxel	Coal mine	23	51
Barbara Erzbergbau A.G.	Düsseldorf	Iron ore	15	25
Rheinische Kalksteinwerke G.m.b.H.	Wülfrath	Limestone	15	32·5
Dolomitwerke G.m.b.H.	Wülfrath	Dolomite	5	25
Vereinigte Ton- und Quarzitbetriebe G.m b.H.	Siegen	Clay, sand	0·8	25
Armco-Thyssen Breitband-Verarbeitung G.m.b.H.	Dinslaken	Finished products	0·2	50
Niederrheinische Hütte A.G	Duisburg	Iron and steel	41·4	96
Other interests	—	—	—	—
Subsidiaries of Niederrheinische Hütte	**Location**	**Business**	**Capital (DM. millions)**	**Per cent interest of Niederrheinische Hütte**
Westfälische Union A.G.	Hamm	Finished products	22	100
Lennewerk Altena G.m.b.H.	Altena	Finished products	2·5	100
Eisenwerk Steele G.m.b.H.	Essen-Steele	Finished products	1	100

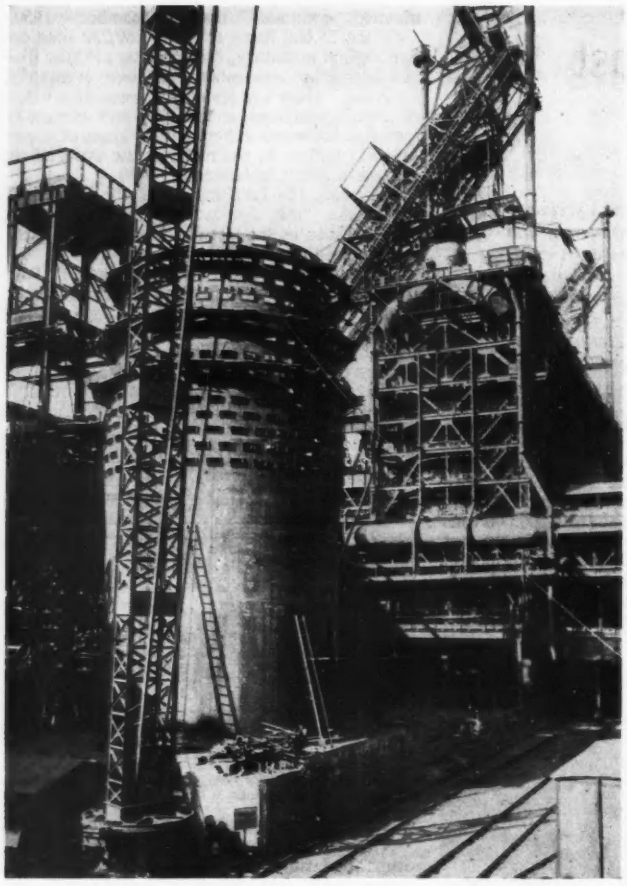


Fig. 2—No. 4 blast-furnace under construction

In the following section will be described a few of the more important aspects of the rebuilt steel works.

BLAST-FURNACES

The latest blast-furnaces to be put into service are the No. 2 which was put back into operation on October 13, 1955, and the No. 4 which came into service on July 5 as the seventh furnace (Fig. 2). No. 2 has a hearth diameter of 6m. It dates back to 1912, was last lined in 1936, and had been put out of action by the air raids of January 1945. The old hearth jacket was used again after repairs and X-ray testing, the hearth being relined with compacted graphite. Including a production of 600 tons per day from this furnace, the pig iron output amounted to 125,000 to 130,000 tons per month.

Like the No. 8 blast furnace—commissioned on January 24, 1955, as the fifth furnace of the rebuilt works—the No. 4 furnace is an entirely new construction. In view of the good economy of the No. 8 (seen in Fig. 1), which has a coke consumption of 820kg per ton of pig iron, the new furnace was built to the same design. Its hearth diameter is 7·5m and its height to the charging platform 37m; the useful volume amounts to 930 cubic metres. In the construction, 3800 tons of steel and 3000 tons of concrete were used, as well as 500 tons of carbon bricks and 6500 tons of refractory. The furnace consumes daily 2400 tons of ore and minerals and 900 tons of coke; output amounts to 1100 tons to 1200 tons of pig iron and 750 tons of slag. The amount of blast used per day is 2,500,000 cubic metres, and 3,000,000 cubic metres of blast furnace gas are produced. Cooling water consumption is 35,000 cubic metres per day.

The works thus possesses at present seven blast furnaces, of which six are in production at any time. These furnaces cost DM.62,000,000 to reconstruct, or DM.30 per ton per annum productive capacity, compared with DM.125 for an entirely new plant including ancillary items such as bunkers, blowers, and gas cleaning plant, but excluding the sinter plant.

The eighth blast-furnace of which mention has been made earlier, has already been ordered. This furnace will be built on new foundation and will incorporate the latest developments in this field. With a hearth of 9m diameter and a daily output of 1500 tons it will be one of the largest of its kind in the world. Its construction will, however, cost only about 70 per cent of that of two smaller furnaces of the same total smelting capacity, and only half the staff will be required.

COKING PLANT

With the coming into service last November of the new No. 1 battery of the August Thyssen coke oven plant, after fifteen months construction, the number of batteries is again five, with a total of 345 ovens. Throughput at No. 1 is 1400 tons of coal per day, a 40 per cent improvement on the previous battery, achieved by increasing the number of ovens to seventy (two blocks of thirty-five) and also in increasing the oven height from 3·50m to 4·50m. The ovens are 0·40m wide and 11m long. Coking time is seventeen hours, daily output 1050 tons.

Of particular interest is the coal storage tower, the first in Germany to be built of prestressed concrete. The cross section of the 48m high tower is in the shape of a figure 8, the diameter of each of the two cylindrical bunkers which form the tower, is about 14m. Both bunkers are lined with glass to facilitate cleaning, and hold 4000 tons. They are automatically filled by means of conveyor belts. Total coke output during 1955-56 from the whole of the plant was 1,200,000 tons.

(To be continued)

E.C.E. Committee on Electric Power

On October 10, at the Palais des Nations, Geneva, a celebration was held to mark the tenth anniversary of the United Nations Economic Commission for Europe's Committee on Electric Power. The meeting, which was presided over by the present chairman of the committee, Mr. R. Hochreutiner, opened in the presence of a large gathering, representing most European countries, governments, private or nationalised undertakings, the specialised agencies of the United Nations, non-governmental organisations and the Press.

In his opening speech, Mr. Tuomioja, executive secretary of the Economic Commission for Europe, pointed out that the instrument that had been perfected by the committee through the setting up of *ad hoc* groups of experts was both flexible and efficient. Subsequent speakers then dealt with various aspects of the development of electric power in Europe at the end of the second world war and before the Committee on Electric Power had been established. They gave some consideration, moreover, to future prospects in that field. The texts of the statements will be published by the secretariat in the near future. Lastly, Mr. Pierre Sevette, Director of the Energy Section of E.C.E., after giving an outline of the committee's achievements, described the underlying principles of its permanent task.

E.C.S.C. Mine Safety Commission

The permanent body on mine safety—the Mine Safety Commission—set up by the European Coal and Steel Community, decided at its first meeting, on September 26, to try to find ways of organising mutual aid between the Community's mine rescue centres, and in particular to draw up a mobilisation plan for rescue services. This task is to be carried out by a special committee comprising representatives of the regional and national rescue services of the Community countries. The committee will gather information on rescue equipment and methods in each coal field, and undertake a systematic comparison of them. It was also decided to set up special committees to examine the action to be taken on the resolutions of the Mine Safety Conference which submitted its report to the High Authority in March, 1957; to draw up reports after any accident which occurs; and to make a study of accident statistics.

The Commission heard a report from the High Authority on progress made so far in research on the effect of the wage structure, and particularly of piece rates, on safety, and decided to call a second plenary session as soon as sufficient data were available.

Monsieur Marcel Gerlache, of the High Authority's labour problems division, was nominated secretary of the Commission. The Commission comprises delegates nominated by the governments of the Community's six member countries to represent the mines administration, and employers' and workers' organisations, as well as representatives of the United Kingdom and the International Labour Office.

Ball Thrust Bearing for High Speeds

The high spindle speeds possible when using sintered carbides and other new materials for cutting tools in lathes and other machine tools have led the Swedish S.K.F. Ball-Bearing Company (A. B. Svenska Kullagerfabriken, Gothenburg) to develop a novel type of ball thrust bearing with a contact angle of 60 deg, in place of the "Series 511" single thrust ball-bearings introduced in the 1930s. These thrust bearings are characterised by simple design, which facilitates the manufacture of extra precision bearings, and by the large number of balls used, which means that they deflect very little under load. However, their relatively low speed limit and the fact that they are not sufficiently rigid for heavily loaded spindles, have restricted their use in modern machines. The new bearing, while still having minimum deflection characteristics, thanks to the large number of balls used, is claimed to operate satisfactorily at considerably higher speeds. It is manufactured in two standards of precision, S.P. (special precision) and U.P. (ultra precision). The former are intended for use in lathes, milling machines, and other applications where moderate demands are made on running accuracy, while U.P. bearings are for machines employed in manufacturing gauging tools, jig borers, roll grinding machines, and similar machines requiring the very highest standards of running accuracy. Angular contact thrust ball bearings are normally supplied as double thrust units complete with a spacer which fits between the shaft washers. The length of the spacer is such as to give the bearing a suitable pre-load.

International Federation For Automatic Control

On September 11, the International Federation for Automatic Control (I.F.A.C.) was founded in Paris. The work of the federation includes the theory and application of control technology, including servo-mechanisms, as well as problems of the construction of apparatus, the processing of information, and the application of electronic calculating machines to the solution of these and related problems. By means of exchanging information between the national organisations, I.F.A.C. hopes to promote the development of the scientific and technical basis of automatic control.

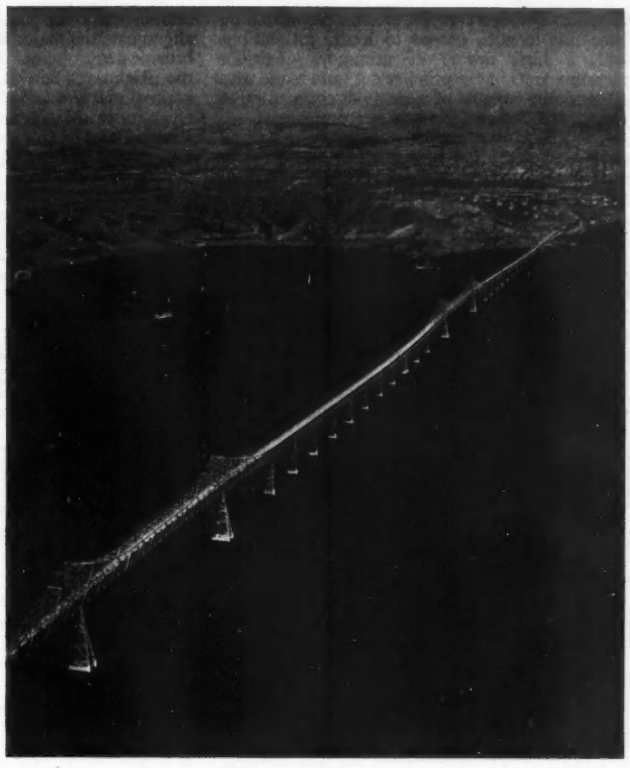
The first congress of I.F.A.C. is to take place in Moscow in 1959 or 1960.

Richmond-San Rafael Bridge

BY OUR AMERICAN EDITOR

No. I

The Richmond - San Rafael Bridge connecting the towns of Richmond and San Rafael across the northern part of the San Francisco Bay in California, was opened to highway traffic on September 1, 1956. The main structure has a length of 21,343ft and the bridge is believed to be the second largest bridge in the world, being exceeded only by the 22,720ft long San Francisco-Oakland Bay Bridge. A main and a secondary channel are each spanned by a three-span structure with, in each case, a 1070ft main span and two 535ft spans; vertical clearances above the channels are 185ft and 135ft, respectively. Initially, only the upper deck of 36ft width was opened; the lower deck, also of 36ft width, was completed in August, 1957, and the bridge now has six 12ft traffic lanes in operation.



SAN FRANCISCO BAY, one of the world's largest harbours, extends north and south on either side of the Golden Gate, its only entrance, for a total distance of some 50 miles, and has a maximum width in excess of 12 miles. While this great expanse of sheltered inland water is more than adequate to anchor the fleets of the world, it is a serious impediment to the free movement of people and goods between the highly developed communities on its shores. Early traffic was served by ferries, both passenger and vehicular, but the people looked forward to a day when bridge crossings would eliminate the periodic delays and inconveniences of ferries. Although bridges crossed the southern part of the bay in the 1920s, the demands for a central crossing were not met until 1936, when the San Francisco-Oakland Bay Bridge joined the two most highly developed areas on either side of the bay. But the phenomenal and continuing increases in population, the everyday use of the motor-car, and the higher integration of the entire bay area demanded bridge crossings at other points not within economic range of the Bay bridge and inadequately served by existing ferries.

One such bridge crossing, from Marin to Contra Costa County, in the general vicinity of the Richmond-San Rafael ferry, had long been considered. Following an initial appropriation by the state legislature, the California Toll Bridge Authority authorised the Department of Public Works to proceed with preliminary engineering studies for a bay crossing between Marin and Contra Costa Counties. The California director of public works assigned the task to the Division of San Francisco Bay Toll Crossings. The division's report of January 1, 1951, recommended the financing and construction of a toll highway bridge to follow substantially the same route as the Richmond-San Rafael ferry from Point San Quentin in Marin County, to Castro Point in Richmond, Contra Costa County. The California Legislature then appropriated additional funds for surveys, plans and other engineering expenses necessary to effect the construction of the Richmond-San Rafael Bridge. In the final development, the bridge was designed as a six-lane, double-decked structure; however, initially, only the upper deck was constructed. The resulting two 18ft lanes, one in either direction, provided sufficient width to allow safe passage of traffic around stalled vehicles adjacent to the curb. Now that the volume of traffic warrants it, the lower deck has also been constructed and the bridge completed to provide a six-lane structure with the upper deck carrying westbound and the lower deck eastbound traffic. The approaches have also been expanded to six-lane capacity.

The California Toll Bridge Authority authorised an issue not exceeding 72,000,000 dollars of Richmond-San Rafael toll bridge revenue bonds and the first stage of construction was financed from the sale of 62,000,000 dollars of bonds of this authorised issue, the final stage being financed from the sale of the additional 10,000,000 dollars of bonds. The delivery of the proceeds from the first sale and the signing of the substructure and superstructure contracts, comprising more than 80 per cent of the estimated contract work, were effected on February 26, 1953.

Fig. 1—Map of bridge site and vicinity

A map showing the bridge site is reproduced herewith. The surveys for the project were predicated at points on the earth's surface as expressed in the California co-ordinate system. The use of this system was defined by legislative act, entitled "State-wide System of Plane Co-ordinates." The Richmond-San Rafael Bridge is the first major bridge in the state for which locations were based on this uniform co-ordinate system.

The first work included the foundation explorations. Points on the 4-mile water crossing were positioned by three-point fixes from established shore stations. The data furnished was required in the preparation of contract plans and specifications. Prior to contract construction the survey section was engaged primarily in obtaining topography, establishing bridge alignments to fit existing conditions, establishing accurate bench marks on land at the site, and other survey work essential to orderly progress in the preparation of designs and specifications. The horizontal control of alignment and pier spacing required the establishment of a complex triangulation survey net. Due to the small tolerances permitted in the steel structures, the triangulation had to be developed to the highest standard of accuracy obtainable in geodetic surveying. The accuracy of a triangulation net is, to a considerable degree, dependent upon the position of the base line selected, and upon the accurate determination of the base line length. For long over-water crossings, involving close tolerances in structure lengths, two base lines are often utilised. For the present triangulation net, a primary base line was selected which is on level ground adjacent to a main line railway in Richmond. The distance between the end stations of the base line was measured as 10,270·397ft. A secondary base line was selected to be run on the flat land north of Sausalito on the westerly shore of Richardson Bay. Its length was measured as 8,235·482ft.

The measurements of the base lines were made in the early daylight hours when the adverse effects of wind and temperature were at a minimum. Further precautions to ensure accuracy were the use of an invar tape, and of weights, in lieu of the more commonly used spring balances, to maintain constant tape tension. Precise instrumental observations of angles for all triangles of the net and the calculation of

distances between stations therein, predicated on base line lengths, served to locate all stations with a high degree of accuracy. Angular measurements in the primary net were made with a theodolite capable of a single direct reading to the nearest one-tenth second of arc.

To locate any given pier for the water portion of the crossing, the triangulation was planned so that intersecting sights from at least four primary stations could be used. The final locations of the anchor bolts and of the bases for the steel towers were determined from triangulation control points established on the permanent portions of each pier. In addition to the triangulation control, direct measurements between piers were made, wherever practicable. To assist in the survey control of pier locations during construction of the water portion of the crossing, the specifications provided that the contractor should install stable survey platforms, or other devices, necessary for the control of construction at each pier. Vertical control for the piers and other work was attained by running precise level circuits from United States Coast and Geodetic Survey elevations to bench marks near the shore lines at the site. From these bench marks extensions were made to other work by the usual levelling methods or to the piers by reciprocal levels. The elevations established by reciprocal levels across the Bay were tied into the shore bench marks previously established.

Design of Bridge

The detailed bridge alignment was established to satisfy the following general characteristics : that it start from the vicinity of Point San Quentin ; cross the primary navigation channels at right angles, as nearly as possible ; and intersect the eastern shore some 1200ft south from Castro Point. Two primary alignment features resulted from such criteria. The first was that an alignment which crossed navigation channels approximately at right angles and led to the bridgehead at Point San Quentin, required a curve in the bridge extending westerly from the west navigation channel. The second was that the alignment 1200ft south from Castro Point required that a " fill " be constructed extending into the bay to provide an area for the toll plaza and toll collection facilities as well as an advantageous position from which to develop the Richmond approach alignment. With the establishment of these bridge and approach alignments the major elements of project lengths became determinate. The overwater structure of the Richmond-San Rafael Bridge had to be approximately 4 miles in length, from Point San Quentin in Marin County to the vicinity of Castro Point in Contra Costa County ; and the total length of the project, including approaches, had to be 5½ miles.

Commencing at Point San Quentin, the bridge consists of 2800ft of trestle approach, which in turn connects to 1900ft of 100ft girder spans (piers 1–19). The girders are connected to the cantilever structure over the main navigation channel by 4100ft of 289ft truss spans (piers 19–33). The span of the cantilever structure is 1070ft centre to centre of the piers, with anchor arms of 537ft, providing 1000ft of horizontal clearance and 185ft of vertical clearance for shipping. Between this structure and the cantilever span over the secondary, or easterly navigation channel there are 3000ft of additional 289ft truss spans (piers 36–46). The secondary channel cantilever has spans as noted for the main channel, but vertical clearance is limited to 135ft. From this location to the vicinity of Castro Point, in Richmond, there are 3500ft of 289ft simple truss spans (piers 49–61) and 1700ft of 100ft plate girder spans (piers 61–78), terminating the over-water structure on an earth fill.

The project also includes connecting highway approaches between the bridgeheads and State Route 69, both in Marin and Contra Costa Counties, as well as administration and maintenance buildings, toll collection, and other facilities. The roadways on the bridge and approaches thereto were built to California " freeway " standards and afford the only route in the area with grades of 3 per cent or less. A grade separation structure, connecting the bridge approach (State Route 69) with U.S. Highway 101, has been constructed on the west side of the bay by the division of highways. On the east side a new section of " freeway " has been built connecting the toll plaza of the bridge with State Route 69 in Richmond. Grade separation structures have been provided for the orderly dispersion of traffic to the city streets.

Bridge Substructure

The substructure consists of sixty-two bell piers, eight cofferdam piers and nine land piers, all bearing on steel H-piles driven into hard strata. The foundation conditions for the piers carrying the 18,500ft of steel spans may be summarised as follows : water up to 50ft in depth covers soft clays and silts, which extend to bedrock or to compacted sands and gravels at varying elevations. Bedrock underlies two-thirds of the crossing at practicable foundation depths ranging from 40ft to 210ft below mean sea level datum. Compacted sand and gravel strata underlie the central portion of the crossing at elevations of minus 140ft to minus 150ft and extend to much greater depths.

Using specified bearing values for bedrock, compacted sands and gravels, or for steel H-piles driven into hard strata, a number of piers were designed to meet typical conditions at various locations. These designs were evaluated on the basis of relative costs, appearance, construction time, adaptability to construction schedules and availability of restricted materials. Included in the piers designed and analysed were caissons, extending directly from the water surface to the hard strata of bedrock or sands and gravels, and cofferdam and bell piers supported on steel H-piles driven into the hard strata. Early in the studies it became evident that caisson piers were not economical. Studies of cofferdam and bell piers had to be made in more detail to reach the ultimate logical decisions.

It was concluded from these studies that cofferdam piers could be used to advantage where bedrock was close to the surface in the shallow waters near shore. For practically all other locations bell piers were found to be more economical. Bell piers were therefore designed for all such locations to realise the increased economy resulting from the duplication of units. It is worthy of note that for several large bridges, in the eastern United States, with site and foundation conditions similar to those of the Richmond-San Rafael Bridge, bell piers were also utilised. In addition to economy, the constructional aspects of bell piers permitted maximum flexibility in developing the substructure and superstructure construction schedules.

Intimately related to and considered in the designs and specifications for the piers was the construction method to be employed. Since construction of piers on land or in water in cofferdams is conventional, only the general bell pier construction procedures considered in developing plans and specifications will be noted

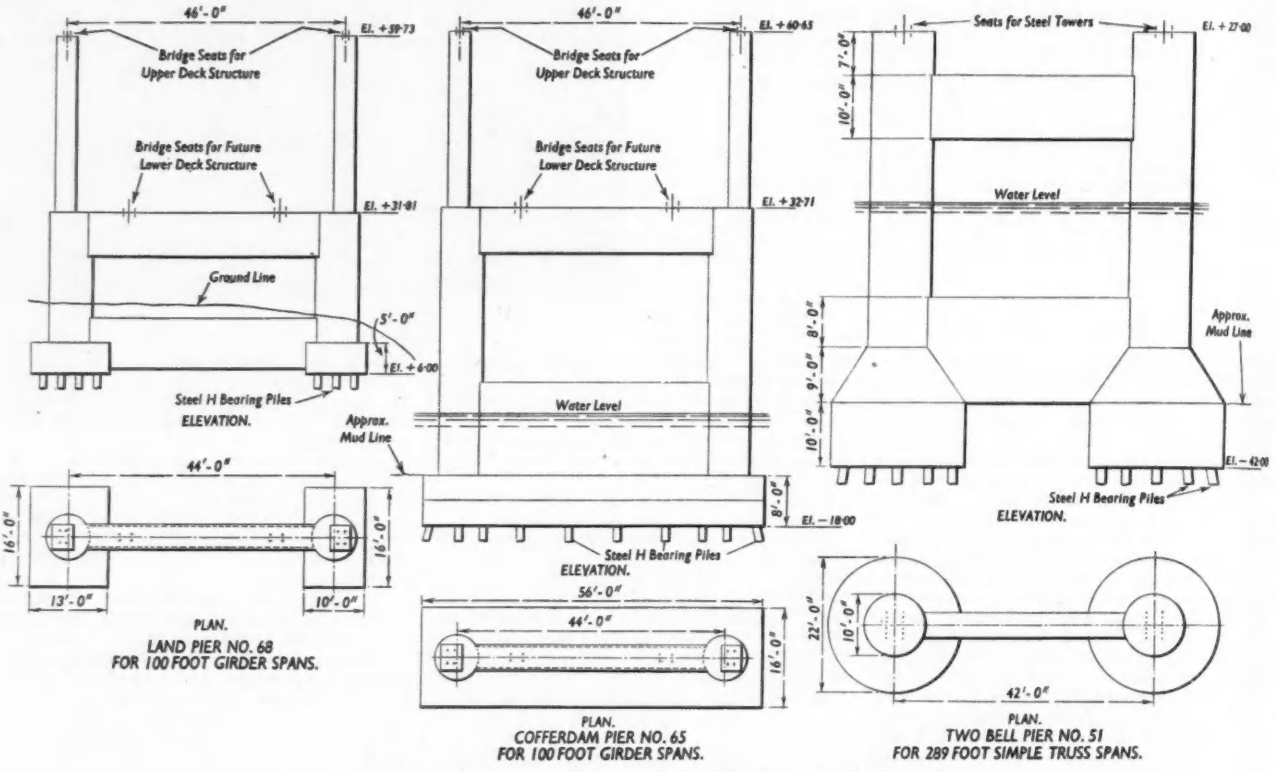


Fig. 2—Three basic pier designs used in the substructure of the bridge

here. In outline, the procedures, or steps, include : excavation of soft clays and silts at each pier site to about 12ft below the mud line ; driving of temporary timber piles to support a mat or grid at the level of the bottom of the pier concrete, some 10ft below the mud line ; emplacement of grids accurately spotted and held, and slotted to fix the position of the permanent steel H-piles ; driving of the steel H-piles ; setting of steel or concrete shells on the grids, either in segments or extending to above the water surfaces ; emplacement of a lift of tremie seal concrete inside the shells and extending upwards 5ft from the grid ; after seal concrete is hardened, extending the tremie concrete inside the shells and diaphragms to an elevation above the water surface, and completing the

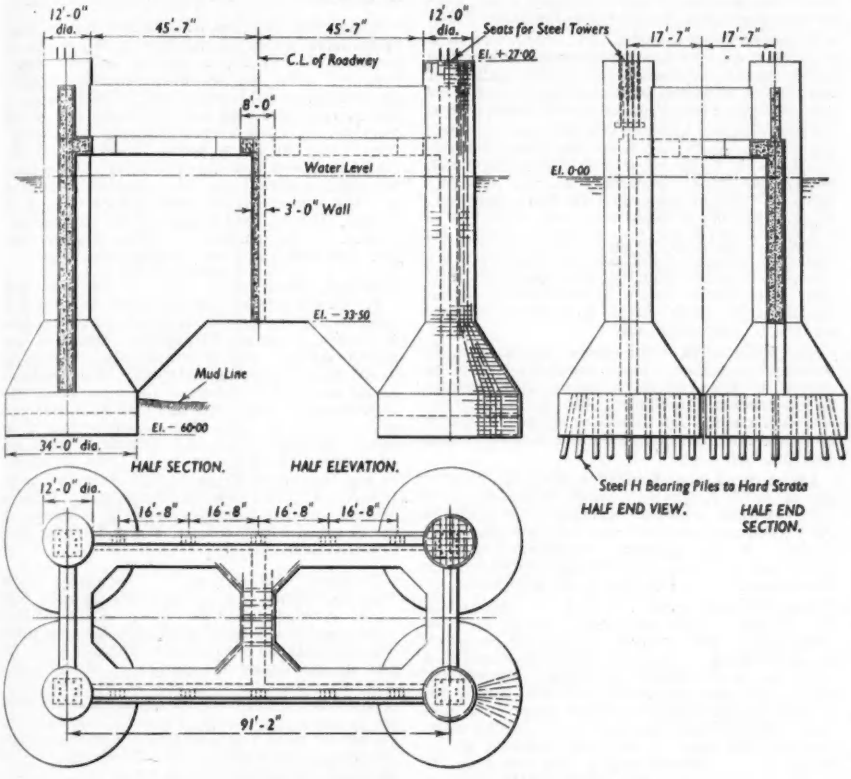


Fig. 3—Four-bell pier design used in the substructure of the bridge

concrete pier by conventional construction methods to the bridge seat elevations where superstructure loads are imposed. To induce the most competition in tendering on the bell piers, the designs and specifications were prepared so that a bidder was permitted maximum latitude in his choice of a method of constructing the bell piers to the lines and grades shown.

Bridge Superstructure

The steel superstructure work consisted of three distinct phases : two double-decked cantilever structures, thirty-six single-decked 100ft plate girder spans, and thirty-six double-decked 289ft truss spans. It also included towers for the spans, steel painting, and the lightweight concrete deck for the over-water crossing of the bridge. The clearances, both horizontal and vertical, of the cantilever spans over the two main channels were fixed by navigation interests. These requirements were that the spans over the main channels each provide 1000ft of horizontal clearance, and that vertical clearances be 185ft for the westerly and 135ft for the easterly navigation channel. The locations of these spans were fixed by the defined channels. Since the required horizontal navigation clearances were the same at each of the channels, and since these controlling conditions were similar, the two cantilevers each have a main span of 1070ft centre to centre of piers and anchor arm spans of 537ft.

Economy and appearance were two of the major factors considered in selecting the truss spans which make up the greater part of the bridge crossing. Preliminary studies were made on span lengths of 289ft and 509ft. These studies demonstrated that 289ft truss spans were more economical when the combined costs of piers and spans were considered. Further studies were made on truss spans of 200ft, 250ft and 320ft, with piers designed accordingly, to verify the selection of the 289ft span. Although 250ft trusses could have been used in certain places, it was decided that the economies of duplication governed and that only one length of truss should be used. The 289ft truss was, therefore, selected. Another economic consideration was the number of panels required for the 289ft truss. An eight-panelled and a ten-panelled truss were designed, and although the ten-panelled truss required less material, the increase in fabrication and erection costs more than offset the saving in material. Consequently, the eight-panelled truss was selected.

Since the 289ft truss spans were to be constructed for two levels of roadway, transition sections of shorter single-decked run-off spans were required to bring both roadways to the same level near the shores. This was accomplished by the use of single-decked plate girder structures on piers spaced at 100ft centres. In every other span these girders are continuous over two piers. In the intermediate spans, cantilever extensions of the continuous girders carry a short suspended span. The continuous girders are duplicates, as far as practicable. Changes in horizontal and vertical alignment are made by varying the lengths of the short suspended spans and the elevations of the bridge seats on the piers.

Several designs of lightweight decks were studied. Based upon these studies, a reinforced lightweight concrete deck was selected. The concrete deck on the 289ft and on the cantilever spans is 6in in thickness and includes a ½in sand-cement mortar wearing surface. On the girder spans, the slab thickness is 10½in and also includes a ½in wearing surface. Experience gained from the San Francisco-Oakland Bay Bridge has demonstrated the reliability of such a concrete deck constructed with a mortar wearing surface.

The bridge and approach alignments required the construction of a mole fill extending into the bay in the vicinity of the eastern bridge terminus. Such a mole fill had to provide a large land area at a given elevation to accommodate services and structures for toll collection, traffic dispersion, separation structures and administration and maintenance buildings. In order to stabilise the possible settlement of the fill prior to further construction thereon, this work was scheduled for completion early in 1954. To meet these requirements, a mole fill was designed, 1600ft in length, generally parallel to the shoreline with a maximum width of 200ft at elevation plus 38ft. The width was adequate for initial construction in which eight toll collection lanes were provided for the two 18ft lanes of traffic on the upper deck of the bridge. At a later time, the fill was widened to its full width to accommodate sixteen toll collection lanes and the approaches thereto. Within the planned fill area the water had a maximum depth of 7ft. Below the water, soft materials extended practically to bedrock at depths of a few feet near the shoreline and ranging to 45ft below datum in the outer portions.

(*To be continued*)

Aeronautical Research Meetings in the U.S.A.

The Advisory Group for Aeronautical Research and Development (AGARD.) of the North Atlantic Treaty Organisation (NATO) will hold its seventh general assembly in Washington, D.C., on November 25–26. The general assembly is held annually in different NATO countries : the meetings this year in the United States will begin on November 18 with visits to appropriate research and development establishments.

Dr. Theodore von Kármán, chairman of AGARD, will preside over the formal opening of the general assembly at the Shoreham Hotel, Washington, on the morning of November 25.

Representatives of the North Atlantic Treaty Organisation, the United States Government, and the armed services will participate in the opening ceremonies. Following the welcoming speeches, General Nathan F. Twining, chairman of the joint chiefs of staff, will give an address on the development of air power in the United States.

The afternoon session will be devoted to a round-table discussion on the general theme, "towards higher altitude." The chairman of this session will be Dr. Hugh L. Dryden, director of the National Advisory Committee for Aeronautics. Introductory talks, followed by general discussion, will be given on :

"Aerodynamics of Low Density Media," by Professor G. N. Patterson, Director, Institute of Aerophysics, University of Toronto, Canada ; "Propulsion at High Altitudes," by Monsieur F. Florio, Technical Director, Société d'Etudes pour la Propulsion par Réaction, and Messieurs M. Barrère and R. Siestrunck, Office National d'Etudes et de Recherches Aéronautiques, France ; "Physics of the Stratosphere and Ionosphere," by Professor F. Dieminger, Max-Planck Institute, Germany ; "High Altitude Flight Testing," by Major I. C. Kincheloe, Jr., and H. M. Drake, United States ; "Aeromedical Problems of Flight above the Atmosphere," by Colonel P. A. Campbell, U.S.A.F., Headquarters, A.F.O.S.R., Air Research and Development, U.S.A.F.

Reports on AGARD activities will be given by the panel chairmen and the director on the morning of Tuesday, November 26.

At the same time, meetings of panels will take place. The combustion and propulsion panel will hold its twelfth meeting, with two days' technical session on November 21–22, and a business session on the Saturday. The aeromedical panel will hold its eleventh meeting on November 26–27 ; it will be devoted to a symposium on "aeronautical preventive medicine," the six papers beginning and ending with addresses on the application of the subject in the United States Air Force and Army, respectively.

Personal and Business

Appointments

MR. T. MURRAY NIVEN has been appointed a director of Shaw Petrie, Ltd.

MR. C. R. WHEELER has been appointed a director of Geo. Wimpey and Co., Ltd.

MR. D. L. JONES has been appointed road transport engineer of the Aluminium Development Association.

MR. R. J. FOSTER has been appointed director and general manager of British Oxygen Aro Equipment, Ltd.

MR. P. S. W. SWABEY has been appointed assistant general sales manager of the British Aluminium Company, Ltd.

MR. F. G. GOODENOUGH, managing director of Goodenough Pumps, Ltd., has been appointed a director of Power Installations, Ltd., Leicester.

METROPOLITAN-VICKERS ELECTRICAL EXPORT COMPANY, Ltd., has announced the appointment of Mr. W. A. Hardman as manager, eastern division.

VERITYS, Ltd., has announced that Mr. H. Lister, A.M.I.E.E., has been appointed branch manager of its Bristol office, and Mr. F. M. Duke, branch manager of its Glasgow office.

THE NATIONAL ASSOCIATION OF MARINE ENGINE-BUILDERS has announced that Mr. James Ferrier has been elected chairman for 1957–58, and Mr. E. W. Parry, vice-chairman.

LONDON TRANSPORT has announced the appointment of Mr. H. P. Steele as divisional superintendent "B" division, (Northern and Northern City Lines) with the rank of principal executive assistant.

MR. M. SEAMAN has relinquished his appointment as director and general manager of British Oxygen Engineering, Ltd., having recently become director and general manager of British Oxygen Gases, Ltd. (equipment division).

BRITISH RAILWAYS, LONDON MIDLAND REGION, has announced that the following divisional traffic managers have been appointed: Mr. T. P. Strafford, Nottingham, Mr. R. L. E. Lawrence, London, and Mr. M. G. E. Lambert, Liverpool.

JACKSON BOILERS, Ltd., has announced the following appointments: Mr. David Brooke, chairman; Mr. C. W. Mustill, managing director; Mr. Frank Cooke, sales director; and Mr. E. Gudgeon, works director. Mr. E. C. King is director and secretary.

THE CENTRAL ELECTRICITY AUTHORITY states that the Electricity Council has announced the following appointments: Mr. R. A. Finn, secretary and solicitor; Mr. A. M. Scott, financial adviser; Mr. W. B. Noddings, commercial and development adviser, and Mr. D. G. Dodds, industrial relations adviser.

THE BOARD OF TRADE announces that the president has appointed Major Richard Miles and Sir Owen Wansbrough as part-time members of the National Research Development Corporation for three years, and has renewed the part-time appointments of Professor P. M. S. Blackett, Mr. J. F. Lockwood and Sir Rowland Smith for a further two years, and of Sir John Duncanson for a further one year.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has announced the appointment of Mr. H. B. Gough, Assoc. I.E.E., as sales manager, scientific apparatus and X-ray departments. Mr. W. J. Brown, A.M.I.E.E., continues as assistant sales manager, scientific apparatus department (Manchester), and Mr. G. F. Gribbin, A.M.I.E.E., has been appointed assistant sales manager, X-ray department (London). These appointments follow the recent retirement of Mr. J. W. Buckley, formerly sales manager, scientific apparatus department. Mr. R. S. Clark, A.M.I.Mech.E., has been appointed superintendent, scientific apparatus department, Barton Dock Road Works.

Business Announcements

MR. D. MANSELL, executive director of National Gas and Oil Engine Export, Ltd., has left for a sales tour of Africa and the Middle East.

MR. HAROLD H. SPENCER, M.I.E.E., has left by air for Peking. His visit is being made at the invitation of the Chinese Ministry of Foreign Trade.

HARTONS INSTALLATIONS, Ltd., has opened additional offices at 66, Carver Street, Sheffield (telephone, Sheffield 27790), to cover the north-eastern area more efficiently.

VISCOUNT KNOLLYS, chairman of Vickers, Ltd., has left by air to visit South America. He will visit Venezuela, Colombia, Peru, Chile, Argentina, Uraguay and Brazil.

WATSON BROTHERS (LONDON), Ltd., 12, Kingly Street, London, W.1, states that it has been appointed sole concessionaires for London and S.E. England for Duplex Electric Tools, Ltd., Purley.

EVERSHED AND VIGNOLES, Ltd., states that its western area offices have been moved from Shipley Road, Westbury-on-Trym to the Stock Exchange Buildings, St. Nicholas Street, Bristol, 1.

LUMENATED CEILINGS, Ltd., Alliance House, Caxton Street, London, S.W.1, states that it has formed a subsidiary company in Germany entitled Licht-Decken G.m.b.H., 123, Hansaring, Cologne.

MATERIALS HANDLING EQUIPMENT (GREAT BRITAIN), Ltd., has been appointed sole concessionaire for the United Kingdom of the "Traveloader" fork-lift carriers made by the Baker-Raulang Company, Cleveland, Ohio, U.S.A.

THE BRITISH ALUMINIUM COMPANY, Ltd., has announced that its Midland branch sales office has been transferred from Lansdowne House, 41, Water Street, Birmingham, 3, to 109, Hagley Road, Edgbaston, Birmingham, 16 (telephone Edgbaston 4521).

HAYWARD TYLER AND CO., Ltd., Luton, states that it has entered into a licensing agreement with A/B de Lavals Angturbin, Sweden, for the manufacture of vertical and horizontal steam turbines primarily for use as drivers of centrifugal cargo and ballast pumps.

THE HOFFMANN MANUFACTURING COMPANY, Ltd., states that it has moved from 217, Westgate Road, Newcastle, to larger premises at Rutherford Street, off Westgate Road, Newcastle (telephone, Newcastle 23041/2). The new office and stockroom is under area manager Mr. W. N. Mills.

ROTOL, Ltd., Gloucester, states that it has formed a subsidiary company, Rotol Incorporated. Its primary purpose will be to render after-sales service and technical assistance to airline operators and aircraft manufacturers using Rotol and British Messier equipment in the Americas.

THE PULSOMETER ENGINEERING COMPANY, Ltd., Reading, states that it has acquired the controlling interest in G. S. Tett and Company, Ltd., Bedfont Lane, Feltham, Middlesex. Mr. F. B. Duncan, chairman, and Mr. J. S. Woodrow, managing director of Pulsometer, have joined the board of G. S. Tett and Co., Ltd.

LISTER BLACKSTONE RAIL TRACTION, Ltd., Imperial House, 15-19, Kingsway, London, W.C.2, is a subsidiary company which has been formed to handle the rail traction application of Lister and Blackstone diesel engines and other equipment manufactured by R. A. Lister and Co., Ltd., Dursley, Gloucestershire, and Blackstone and Co., Ltd., Stamford, Lincolnshire.

ROSS COURTNEY AND CO., Ltd.—On October 23, Ross Courtney, Ltd., gave a reception to mark the opening of its new factory extension at 25, Ashbrook Road, London, N.19. The company which is a subsidiary of Southern Areas Electric Corporation, Ltd., 28, Queen Anne's Gate, London, S.W.1, this year celebrates its diamond jubilee. Since its foundation in 1897, it has supplied industry, notably the motor, electrical and later the electronic industry, with a large variety of small, usually repetitive items, of which, including variants, about 10,000 items are stated to be in production or on call.

Contracts

MCCRACKEN AND SON (MAIDENS), Ltd., is to undertake a contract for the improvement of the Gretna–Stranraer–Glasgow–Stirling trunk road (A.77) from just south of the Wigtown–Ayr County Boundary northwards to milestone "Ballantrae 8." The works will be carried out under the supervision of Ayr County Council, as agent for the Secretary of State for Scotland, and will provide for the realignment of the road for a distance of about one and a quarter miles with the construction of a 24ft carriageway on the improved alignment. The estimated cost is about £100,000 and the works will take about eighteen months to complete.

Miscellanea

VACUUM CASTING OF HIGH DUTY METALS.—Our issue of September 27 last referred, on page 448, to the arc and induction furnaces for vacuum melting of metals by William Jessop and Sons, Ltd. We now learn that the induction furnaces only are National Research Corporation designs: the arc furnaces were built by the operators to designs prepared in consultation with the Titanium Metals Corporation in the U.S.A.

THANET WATER BOARD.—A result of recent governmental policy aimed at the "rationalisation" of the water industry has been the regrouping of thirty undertakings in Kent into nine new undertakings. One of these new bodies, the Thanet Water Board, has now published its first annual report, in which the preliminary work of organising the new board is discussed, and the results of the first year of its operation to March 31, 1957, are recorded. The chairman states that the difficulties met were fewer than had been anticipated. The Board's area covers almost 100 square miles, including Margate, Ramsgate and Broadstairs. The area is characterised by a high summer demand, estimated at 8·9 m.g.d. as against 5·2 m.g.d. in winter.

MULTI-STOREY PARKING GARAGES.—A pamphlet published by the Trussed Concrete Steel Company, Ltd., Truscon House, Lower Marsh, London, S.E.1, contains an article describing the various systems which have been used for designing multi-storey garages. The various ramp layouts which can be used are illustrated, and two systems of mechanical garages, in which cars are taken by lifts and traversing mechanisms to their parking space, are also described. An economic appraisal of the two systems is given.

RECENT DEVELOPMENTS IN BRITISH NAVAL MAIN PROPULSION STEAM TURBINES.—In our issues of October 18 and 25, a reprint of this paper, presented before the Institute of Marine Engineers on October 8 was published. Unfortunately a serious error occurred in reproducing one of the diagrams, Fig. 4, in our reprint, showing heat consumptions. For all values below 10,000 B.Th.U. per shaft horsepower hour the values shown are ten times too high. It should also have been recorded that of the two authors of the paper the late Mr. F. J. Cowlin, O.B.E., M.I.Mech.E., was an associate member of the Institute of Marine Engineers and Mr. A. F. Veitch an associate of that Institution.

BRITISH OFFER FOR COLONIAL URANIUM.—The U.K. Atomic Energy Authority announces that it is ready to buy annually, from existing or future mines in Kenya, Uganda, Tanganyika, Swaziland and British Guiana, chemical concentrates containing up to 500 short tons of uranium oxide, U_3O_8. Contracts would cover a ten-year period from the coming into production of a mine, provided that the end-date did not fall beyond 1972. The Authority reserves its right to include other British colonial or dependent territories in the offer at any time. Inquiries relating to East Africa should go to the Officer in Charge, U.K.A.E.A. Office, Dodoma, Tanganyika. Inquiries relating to other territories should be addressed to the Principal Metals Officer, U.K.A.E.A., St. Giles Court, London, W.C.2.

NATIONAL FEDERATION OF ENGINEERS' TOOL MANUFACTURERS.—More than 200 members and guests attended the annual dinner of the National Federation of Engineers' Tool Manufacturers which was held in London on Tuesday, October 8. At the end of the dinner the president, Major-General E. P. Readman, said that there would be no formal speeches and in a few well-chosen words he welcomed the guests of the member firms. He said that the Federation owed a debt of gratitude to the previous president, Lord Riverdale, for his valuable work on its behalf during the past few years. As a mark of appreciation for this work he presented Lord Riverdale with a memento in the form of a beautiful silver model of H.M.S. "Uganda," on behalf of the firms represented by the Federation. In thanking Major-General Readman for the model, Lord Riverdale said that he was glad that his association with the Federation would continue in his office of vice-president. Although it was not easy to see into the future, the present position of the tool industry was healthy and was likely to continue so, as tools were and always would be, a basic requirement of the engineering industry.

PROGRESS AT BERKELEY NUCLEAR POWER STATION.—The 200-ton lower dome of the first of the two pressure vessels for Berkeley nuclear power station has been completed. Construction began on May 27. Two short railways were laid (partly over a Bailey bridge) from the centre of the foundations to the dome during the fabrication of the latter, and the journey from the welding site began on October 20. With the dome in position welders have begun to close the gap left in the thermal shield for its admission. The thermal shield has been erected so far to a height of 36ft. A removable roof has been placed on the twelve supporting columns of the shield to form a welding chamber. Welding sets are in place in the gas ducts entering the well under the reactor, and ventilation has been provided. A crane will lift the "lid" of the chamber when new plates are needed. As the vessel rises in a series of five bands (see THE ENGINEER, October 18, page 560), the concrete biological shield, 8½ft thick, is to be built outside the thermal shield. The welding of the lower dome for the second pressure vessel is to be begun on the completed foundations. The retaining walls of the turbine hall are reported to be almost complete, and the sub-foundations for the turbine blocks finished. Excavation for the pump house is proceeding.

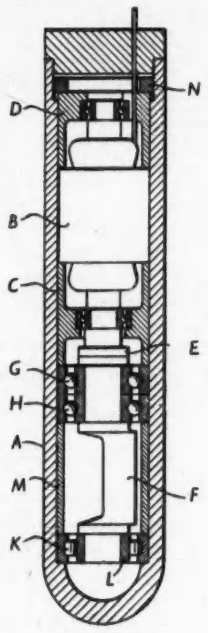
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

VIBRATING MECHANISMS

783,847. May 25, 1956.—VIBRATORS, Jurg Brigel, Stauffacherstrasse 96, Zürich, Switzerland.

The invention relates to bearing arrangements for electrically operated internal vibrators. The drawing shows a sectional view of the bearing arrangement. A vibrator housing *A* is made in one piece and a driving motor *B*, carried by bearing brackets *C* and *D* is mounted within the casing. The motor is connected by a coupling *E* to an out-of-balance body *F*.



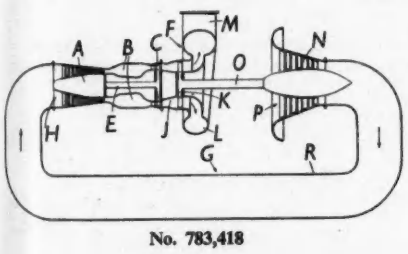
No. 783,847

The body is journalled at one end in fixed ball bearings *G* and *H*. The other end of the body *J* is journalled in a roller bearing *K*, which permits axial displacement of a bearing sleeve *L*. A bearing spacer *M* is disposed between the outer rings of the bearings *G* and *H*, respectively. By tightening a threaded ring *N* into the housing *A*, the outer rings of the bearings are clamped fast between the ring *N* and a shoulder formed in the housing. The bearings *G* and *H* fix the out-of-balance body *F* in its position in relation to the driving motor and the vibrator housing.—*October* 2, 1957.

GAS TURBINES

783,418. February 15, 1954.—A METHOD OF AND MEANS FOR TESTING ENGINES, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventor: Henry Cook.*)

This invention relates to a method of testing under simulated high-speed flight conditions gas turbine engines which are designed for jet propulsion purposes. The drawing illustrates a gas turbine engine under test in one form of apparatus according to the



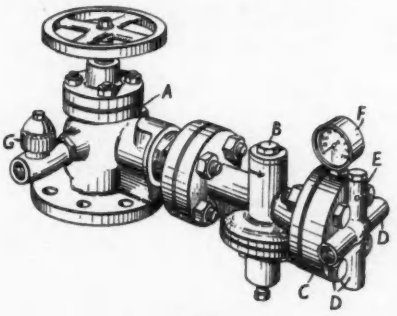
No. 783,418

invention. The engine under test comprises an axial-flow compressor *A*, combustion equipment *B* and a turbine *C*. The turbine *C* is connected to the compressor *D* by a driving shaft *E*. Normally the exhaust gases from the turbine pass through a jet pipe and are discharged from a propulsion nozzle at the end of the jet pipe. However, for the purposes of the test, the jet pipe and propulsion nozzle are removed. The test apparatus comprises an exhaust section *F* for carrying away to atmosphere the exhaust gases from the engine under test and an air supply section *G* for supplying air to the intake *H* of the compressor under conditions simulating the conditions in the air intake at high flight speeds. The exhaust section comprises an annular duct *J* leading from the outlet side of the turbine to a power turbine *K*, the exhaust from which flows into a collector scroll *L* and thence through a delivery *M* to atmosphere. The air supply section *G* comprises an axial-flow compressor *N* of which the rotor is connected to the power turbine *K* by a co-axial shaft *O*, and the intake *P* is open to atmosphere. A delivery conduit *R* connected at its upstream end to the delivery of the compressor *N* delivers air to the intake *H* of the engine under test. Means may also be provided for injecting water into the conduit *R* so that the air being delivered to the intake *H* of the compressor of the engine under test can be cooled by evaporation and also means may be provided for spoiling the efficiency of the compressor *N* so that the temperature of the air leaving it can be varied whilst maintaining a constant delivery pressure. If it is required to test an engine at simulated flight speeds greater than can be obtained by driving the turbine *K* by the exhaust gases as they leave the turbine *C*, fuel may be burnt between the two turbines so as to reheat the exhaust gases prior to their entry into the turbine *K*, thereby making available greater power for driving the turbine. It will be seen that in testing the engine the power for operation of the test apparatus is derived solely from the engine under test and that the whole of the test apparatus can be accommodated within a relatively small space. Another advantage of the arrangement of this invention is that the test apparatus requires no air storage and can readily be employed for production testing of engines.—*September* 25, 1957.

VALVES

783,338. December 4, 1953.—DUST SUPPRESSORS, H. Lindley, Ltd., Empire House, 10, Piccadilly, Bradford. (*Inventor: Harry Lindley.*)

The invention relates to dust suppressors, and its object is to provide a more efficient means of distributing water than has hitherto been used. As



No. 783,338

will be seen from the drawing, a stop valve *A* has connected to its outlet flange a pressure reducing valve *B*, in which the static pressure of the liquid passing through it is reduced. Attached to the outlet flange of the reduction valve is an adapter *C*, which is so formed that on its outer face it has three outlets *D* which connect it to the bore and a pressure release valve *E*. A visual pressure gauge *F* is mounted on the adapter. Mounted on the stop valve *A* is a subsidiary stop valve *G*, which enables water to be drawn off independently from the valve *A*. In use the stop valve *A* is opened and water flows through to the reducing valve *B* and passes into the adapter *C* and thence to hoses attached to the outlets *D* so that up to three hoses can be operated simultaneously; at the same time water at full static pressure can be taken off by connecting the hose to the valve *G*. A modification may take the form of a fire hose connection, in which arrangement the pressure reducing valve is removed and the adapter connected to the stop valve, thereby giving four outlets at full static pressure.—*September* 25, 1957.

METALLURGY

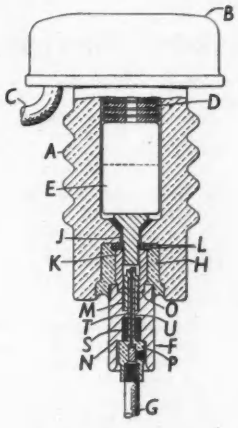
784,101. May 17, 1955.—STEEL WIRE SOFTENING PROCESSES, Cross Manufacturing Company (1938), Ltd., 33, Midford Road, Combe Down, Bath, Somerset. (*Inventor: Roland Claude Cross.*)

The invention concerns a method of and apparatus for softening hard-drawn steel wire. The drawing with the specification shows how wire is passed through a metal tube into which gas is fed and this tube is arranged above an elongated gas burner giving a high and a low temperature section. The metal tube extends from one end of the high temperature section of the burner to a point immediately short of a stream of oil in constant circulation. The burner is so arranged that at the wire entry to the tube the heat is fierce enough to bring the wire to a temperature of 800 deg. to 850 deg. Cent. The wire is cooled as it passes along through the tube and leaves the tube at a temperature of about 380 deg. to 420 deg. Cent. The slow cooling of the wire in the tube after it has reached maximum temperature is a major factor in preventing the formation of martensite, a condition liable to be created by hasty cooling. The quench by the oil stream is advantageous, but not essential. It ensures the prevention of oxidation and enables a shortening of the cooling end of the tube to a limited extent.—*October* 2, 1957.

ELECTRICAL ENGINEERING

782,902. August 9, 1954.—IMPROVEMENTS IN LIGHTNING ARRESTERS FOR ELECTRIC POWER LINES, E.M.P. Electric, Ltd., Garman Road, Tottenham, London, N.17. (*Inventors: Kurt Dannenburg and Ivor Evan Humphreys.*)

The invention relates to improvements in lightning arresters for electric power lines and is particularly concerned with an isolating device for rendering the arrester inoperative in conditions which might otherwise cause damage. The drawing shows a partial section of a lightning arrester to which the isolator device forming the main feature of the invention is fitted. A corrugated ceramic housing *A* is provided with a sealed-on cover cap *B* through which a feed cable *C* for connection to a distribution line is passed. A spark gap assembly *D* is located beneath the cap *B* and is subjected to the action of a spring tending to



No. 782,902

press the gap unit against a non-linear resistor block *E* or in some cases a number of such blocks as indicated by a dotted division line. At the base of the housing *A* is located an isolator device *F* to which an earth lead *G* is connected. The casing *A* is recessed at its lower end at *H* to accommodate the upper part of the isolator unit *F*. A threaded conducting member *J* projects through the base of the casing into the recess *H* and engages a tubular union *K* which seats against the casing *A* by discs *L* of suitable material. The union *K* is threaded internally to engage the threaded upper end of a terminal member *M*, the lower part of which is accommodated in a block *N* of insulating material recessed at its upper end, as shown at *O*, to fit around the lower edge of the union *K*. The block *N* is recessed at its opposite end to accommodate a cable nipple *P* attached to the earth cable *G*. An enlarged housing within the block *N* accommodates a spring *S* which is compressed between the nipple *P* and a radial wall portion in the block so that the spring tends to throw the nipple and the cable *G* downwards. The parts so described are held in the assembled position shown by a length of nickel-chrome wire *T* electrically and mechanically connected both to the cable nipple *P* and to the terminal member *M*. The wire is surrounded for at least part its length by a ceramic tube *U* which is preferably a relatively close or tight fit around the wire *T*. The terminal member *M* is preferably enlarged internally for part of its length, as shown, to accommodate the tube *U*. The recess *H* is preferably filled with a bituminous wax filler. When the conditions arise which are to cause operation of the isolator the flow of earth current through the cable *G* causes heating of the wire *T*, which melts after a delay related inversely to the magnitude of the current flow, with the result that the cable nipple *P* is ejected by the action of the spring *S* and ensures a rapid extinction of the arc.—*September* 18, 1957.

Launches and Trial Trips

RIEVAULX, ore carrier; built by Smith's Dock Company, Ltd., for the North Yorkshire Shipping Company, Ltd.; length between perpendiculars 480ft, breadth moulded 68ft 9in, depth moulded to upper deck 36ft 3in, deadweight 15,500 tons on 28ft 11in draught, service speed 11¼ knots; four main holds, wing water ballast tanks, MacGregor hatch covers, electric deck machinery; three 200kW diesel-driven generators; Hawthorn-Doxford opposed piston, diaphragm, two-stroke oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4450 b.h.p. at 115 r.p.m.—Launch, August 27.

DARTBANK, cargo ship; built by Harland and Wolff, Ltd., at Belfast, for Andrew Weir and Co., Ltd.; length between perpendiculars 450ft, breadth moulded 62ft 6in, depth moulded to upper deck 38ft 6in; two complete steel decks, nine watertight compartments, five main cargo holds, one 25-ton, two 10-ton, twelve 5-ton, two 3-ton derricks, electric winches; three 175kW diesel-driven generators, Harland and Wolff single-acting, two-stroke, opposed piston diesel engine, six cylinders, 620mm diameter by 1870mm combined stroke, 118 r.p.m.—Launch, August 28.

HUNTSVILLE, cargo ship; built by the Burntisland Shipbuilding Company, Ltd., for the Power Steamship Company, Ltd.; length between perpendiculars 450ft 3in, breadth moulded 63ft 10¾in, depth moulded to shelter deck 40ft 5in, deadweight 12,160 tons, draught 27ft 10¼in; five cargo holds, six 5-ton, and four 10-ton derricks, electric deck machinery, three 320kW diesel-driven generators; Hawthorn-Doxford opposed piston oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6600 b.h.p. at 115 r.p.m., arranged to burn heavy fuel.—Trial, August 31.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Nov. 1.—BRISTOL AND WEST OF ENGLAND BRANCH: Grand Hotel, Broad Street, Bristol, "The Work of the National Fire Service," 8 p.m. ★ LIVERPOOL AND DISTRICT BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, "Electronic Instrumentation and Control," A. Williams, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, Nov. 1.—S. MIDLANDS SECTION: Technical College, Wulfruna Street, Wolverhampton, "Cold Cathode Switching Techniques," J. H. Beesley, 7.15 p.m. ★ N.E. SECTION: Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, "Electronic Control of Machine Tools," H. Ogden, 6 p.m.

Thurs., Nov. 14.—N.W. SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, "Some Electronic Techniques Used in Textile Research," J. B. Todd, 6.30 p.m.

CHEMICAL SOCIETY

Thurs., Nov. 7.—Chemistry Department, University College, Gower Street, London, W.C.1, A Symposium on "Newer Preparative Methods in Organic Chemistry," 2.15 p.m. and 5 p.m.

DIESEL ENGINEERS AND USERS ASSOCIATION

Thurs., Nov. 21.—Caxton Hall, Westminster, London, S.W.1, "Fuel Injection Equipment," G. R. Green, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Wed., Nov. 6.—CARDIFF CENTRE: S. Wales Electricity Board, The Hayes, Cardiff, "Lighting of Shops and Stores," R. L. C. Tate, 6 p.m. ★ EDINBURGH CENTRE: Y.M.C.A. Social Room, 14, South Saint Andrew Street, Edinburgh, "Lighting in Relation to Modern Ceilings and Roofs," Derek Phillips, 6.15 p.m.

Thurs., Nov. 7.—Royal Institute of British Architects, Portland Place, London, W.1, "A Review of Present Architectural Thought and Trends," H. T. Cadbury-Brown, 6 p.m. ★ GLASGOW CENTRE: Lighting Service Bureau of Scotland, 29, St. Vincent Place, Glasgow, C.1, "Lighting in Relation to Modern Ceilings and Roofs," Derek Phillips, 6.30 p.m. ★ NOTTINGHAM CENTRE: E. Midlands Electricity Board, Smithy Row, Nottingham, "Forum—Street Lighting," C. S. Gaunt, B. M. Cobbe, E. Howard and G. C. Small, 5.30 p.m. ★ SWANSEA GROUP: S. Wales Electricity Board, The Kingsway, Swansea, "Lighting of Shops and Stores," R. L. C. Tate, 6.30 p.m.

Mon., Nov. 11.—SHEFFIELD CENTRE: Grand Hotel, Sheffield, Presidential Address, E. B. Sawyer, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Nov. 5.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2, "Lighting Installations for Industry," W. Robinson, 7 p.m. ★ GLASGOW BRANCH: St. Enoch's Hotel, Glasgow, Brains Trust, 7.15 p.m. ★ PETERBOROUGH BRANCH: White Lion Hotel, Church Street, Peterborough, "Flight Testing of High Speed Aircraft," 7.30 p.m.

Wed., Nov 6.—EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, "The Clean Air Act," T. M. Ashford, 7 p.m. ★ LEICESTER BRANCH: Bell Hotel, Leicester, "Training for Managerial Efficiency," 7 p.m. ★ SOUTHERN BRANCH: Polygon Hotel, Southampton, Brains Trust, "Road and Internal Transport with its Associated Equipment," 7.30 p.m.

Mon., Nov. 11.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Manufacturing Experiences," J. Lomax, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Nov. 4.—MERSEYSIDE AND N.W. SECTION: Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "The Free Piston Engine and its Marine Application," P. Watson, 6 p.m.

Tues., Nov. 5.—MERSEYSIDE AND N.W. SECTION: Central College of Further Education, Abbey Road, Barrow-in-Furness, "Boiler Water Treatment," J. F. Colville, 2 p.m.

Tues., Nov. 12.—SOUTHERN JOINT BRANCH: Technical College, St. Mary Street, Southampton, "Cargo Handling and Associated Deck Machinery," J. West, 7.30 p.m.

INSTITUTE OF METALS

Thurs., Nov. 7.—BIRMINGHAM LOCAL SECTION: College of Technology, Gosta Green, Birmingham, "Tool Steel Development," A. P. T. Taylor Gill, 6.30 p.m. ★ LONDON LOCAL SECTION: Royal School of Mines, South Kensington, London, S.W.7, "Refractories," J. White, 7 p.m.

INSTITUTE OF PETROLEUM

Wed., Nov. 6.—26, Portland Place, London, W.1, "Cyclical Fluctuations and Black Oil Demand: An Introduction," G. Chandler and D. W. Lindsell, 5.30 p.m.

INSTITUTE OF PHYSICS

Thurs., Nov. 7.—N.E. BRANCH: King's College, Newcastle upon Tyne, "The Recruitment and Training of Physicists," N. Clarke, 6.15 p.m. ★ STRESS ANALYSIS GROUP: University College, London, W.C.1, "Discussion on "Photoelastic Reflection Technique," introduced by H. Fessler and E. J. Haines, 6 p.m.

Fri., Nov. 8.—MANCHESTER AND DISTRICT BRANCH: Bragg Lecture Theatre, The University, Manchester, "River Waves," M. J. Lighthill, 6.45 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Nov. 7.—Junior Institution of Engineers, Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "A Review of Methods for Odour Control in Refrigerated Space," W. Summer, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Nov. 4.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Use of Plastics in Road Transport," M. D. Curwen, 7.30 p.m.

Wed., Nov. 6.—E. MIDLANDS CENTRE: Mechanics Institute, Nottingham, "Taking Stock on Maintenance," P. H. Wyke-Smith, 7.30 p.m. ★ WESTERN CENTRE: Royal Hotel, Bristol, "The Manumatic Gearbox," P. J. Holman, 7 p.m.

Thurs., Nov. 7.—WEST REGIONAL CENTRE: Liverpool Architectural Society, Bluecoat Chambers, School Lane, Liverpool, 1, "Gas Turbines," J. H. Weaving, 7.30 p.m.

Fri., Nov. 8.—WESTERN CENTRE: Rougemont Hotel, Exeter, "From the Laboratory to the Road," T. I. Fowle, 7 p.m. ★ S. WALES CENTRE: S. Wales Institute of Engineers, Park Place, Cardiff, "Disc Brakes and Independent Suspensions," J. Pearson, 7 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Mon., Nov. 11.—Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "Careers in Agricultural Engineering," the first of a series of lectures on training for a career in agricultural engineering, speakers J. E. Bywater and W. H. Cashmore, 3 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Nov. 5.—NINTH HINCHLEY MEMORIAL LECTURE: Geological Society, Burlington House, Piccadilly, London, W.1, "An Education for Our Times?" R. P. Linstead, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Nov. 5.—Great George Street, Westminster, London, S.W.1, Presidential Address, Sir Arthur Whitaker, 5.30 p.m.

Thurs., Nov. 7.—N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, "The Employment of Contractors' Plant on Civil Engineering and Construction Works," R. H. McGibbon and J. H. Brass, 6.30 p.m.

Tues., Nov. 12.—Great George Street, Westminster, London, S.W.1, "Plastic Design of Pitched Roof Portal Frames," Jacques Heyman, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Nov. 4.—EAST ANGLIAN SUB-CENTRE: Crown and Anchor Hotel, Ipswich, "Colour Television," L. C. Jesty, 6.30 p.m.

Tues., Nov. 5.—E. MIDLAND CENTRE: E.M.E.B. Service Centre, Derby, "Electricity in Modern Commercial Horticulture," C. A. Cameron Brown and A. W. Gray, 6.30 p.m. ★ MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, "The Design of the Control Unit of an Electronic Digital Computer," M. V. Wilkes, W. Renwick and D. J. Wheeler; "A Decimal Adder using a Stored Addition Table," M. A. Maclean and D. Aspinall; "An Accurate Electroluminescent Graphical Output Unit for a Digital Computer," T. Kilburn, G. R. Hoffman and R. E. Hayes, 5.30 p.m. ★ N.W. CENTRE: Engineers' Club, Albert Square, Manchester, "138kV Submarine Power Cable Interconnection between the Mainland of British Columbia and Vancouver Island," T. Ingledon, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson, 6.15 p.m.

Wed., Nov. 6.—N.W. RADIO AND TELECOMMUNICATION GROUP: Engineers' Club, Albert Square, Manchester, "The Importance of Research in Hearing and Seeing to the Future of Telecommunication Engineering," E. C. Cherry, 6.45 p.m. ★ S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Recent Developments in Low-Voltage, High-Rupturing-Capacity Fuse Links," R. H. Dean, 7 p.m. ★ SOUTHERN CENTRE: The University, Southampton, "Frequency-Modulated V.H.F. Transmitter Technique," A. C. Beck, 7 p.m. ★ SOUTHERN CENTRE: R.A.E. Technical College, Farnborough, Discussion on "The Technical Educational Team's Visit to the U.S.S.R.," opened by H. E. Dance, 6.30 p.m.

Thurs., Nov. 7.—ORDINARY MEETING: Savoy Place, London, W.C.2, Discussion of the Report on "The Supply and Training of Teachers for Technical Colleges," introduced by Willis Jackson, 5.30 p.m. ★ MERSEY AND N. WALES CENTRE: Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "A Standard Gas Turbine to Burn a Variety of Fuels," G. B. R. Feilden, J. D. Thorn and M. J. Kempet, 6.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Nov. 4.—N.E. BRANCH: Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Electric Heat-Hreatment Furnaces," J. W. Payne, 7.15 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Nov. 5.—39, Elmbank Crescent, Glasgow, "The Geometry of the Job," W. Heigh, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Nov. 1.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "Street Lighting," Granville Berry, 5.30 p.m.

Tues., Nov. 5.—E. ANGLIA BRANCH: Assembly Branch, Norwich, "Tunelling," J. Kell, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 1.—GENERAL MEETING IN CONJUNCTION WITH THE INTERNAL COMBUSTION ENGINE GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Symposium on Engine Testing, 4 p.m.

Mon., Nov. 4.—N.W. GRADUATES SECTION: M.A.N.W.E.B. Industrial Electrical Service Centre, Paradise Street, Liverpool, "Hydroelectric Power in Scotland," R. Freer, 7 p.m.

Tues., Nov. 5.—COVENTRY A.D. CENTRE: Leofric Hotel, Coventry Address by A.D. Chairman, 7.15 p.m.

Wed., Nov. 6.—INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "The Breakage of Cutting Tools," 6.45 p.m. ★ E. MIDLANDS BRANCH: City Boys' School, Humberstone Gate, Leicester, "Matters for Management," R. Beeching, 7.15 p.m. ★ LUTON A.D. CENTRE: Town Hall, Luton, "Some Important Problems Concerning the Small Utility Car," D. Giacosa, 7.30 p.m.

Thurs., Nov. 7.—EASTERN BRANCH: Town Hall, Luton, "Principles and Applications of Spark Machining," D. W. Rudorff, 7.30 p.m. ★ N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Some Modern Developments in Aluminium Fabrication and Welding," R. Coleman, J. Gregson and G. E. Toms, 6.45 p.m. ★ SCOTTISH BRANCH: Royal College of Science and Technology, Glasgow, "Pressure Vessel Design," W. B. Carlson, 7.30 p.m. ★ YORKSHIRE GRADUATE SECTION: Grand Hotel, Sheffield, "Is Motor Racing Worth While?" Ian Appleyard, 6.30 p.m.

Fri., Nov. 8.—GENERAL MEETING IN CONJUNCTION WITH THE BRITISH NUCLEAR ENERGY CONFERENCE: 1, Birdcage Walk, Westminster, London, S.W.1, "Vacuum Techniques in the Atomic Energy Industry," H. Kronberger, 6 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., Nov. 2.—BIRMINGHAM GRADUATE SECTION: Works Visit to Josiah Wedgwood and Sons, Ltd., Barlaston, Stoke-on-Trent, 10.15 p.m.

Wed., Nov. 6.—NOTTINGHAM SECTION: Victoria Station Hotel, Nottingham, "Manufacture of Tubing," 7 p.m. ★ LONDON GRADUATE SECTION: 10, Chesterfield Street, London, W.1, "Computer-Assisted Production Control," W. J. Kease, 7.15 p.m. ★ S. ESSEX SECTION: Ilford Club, 21A, Balfour Road, Ilford, "Gear Hobbing and Shaping Production Techniques," S. C. Purkiss, 7.30 p.m.

Thurs., Nov. 7.—LEICESTER SECTION: Schofield Building, Technical College, Loughborough, "Fusion Welding of Ferrous Materials," P. H. R. Lane, 7 p.m. ★ READING SECTION: Transport Equipment (Thornycroft), Ltd., Basingstoke, "Lubrication in all its Aspects," S. E. Holmes, 7.30 p.m.

Fri., Nov. 8.—IPSWICH AND COLCHESTER SECTION: Golden Lion Hotel, Cornhill, Ipswich, "Developments in Machine Tool Drive Units," L. A. Childs, 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 1.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Film Evening, "Rubber in Roads" and "Rubber in Engineering," introduced by A. R. Smee, 7 p.m.

Fri., Nov. 8.—INFORMAL MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Television," T. M. C. Lance, 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Nov. 1.—Literary and Philosophical Society, Newcastle upon Tyne, "The Marine Diesel Engine," C. C. Pounder, 6.15 p.m.

Mon., Nov. 4.—Literary and Philosophical Society, Newcastle upon Tyne, "Nuclear Power for the Propulsion of Merchant Ships," S. Livingston Smith and J. E. Richards, 6.15 p.m.

PLASTICS INSTITUTE

Mon., Nov. 4.—MIDLANDS SECTION: Grand Hotel, Leicester, "Thin Wall Mouldings or Fundamental Flow Properties of Polystyrene," M. P. Brown, 6.45 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Nov. 5.—N.W. BRANCH: College of Technology, Sackville Street, Manchester, "Concrete Additives," M. Sandall 6.45 p.m.

Wed., Nov. 6.—N.W. BRANCH: Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "Concrete Additives," M. Sandall, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Nov. 7.—GRADUATES AND STUDENTS SECTION: 4, Hamilton Place, London, W.1, "The Background to Aircraft Specifications," K. W. Clark, 7.30 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Nov. 11.—12, Great George Street, Westminster, London, S.W.1, Presidential Address, W. M. Balch, 5.45 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN

To-day, Nov. 1.—21, Albemarle Street, London, W.1, "Clean Air.—What We Know and What We Do Not Know," Sir Hugh Beaver, 9 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Tues., Nov. 5.—B.I.S.R.A., Hoyle Street, Sheffield, "Schematic Methods of Metallurgical Analysis," D. F. Sermin, 7 p.m.

SOCIETY OF ENGINEERS

Mon., Nov. 4.—Geological Society, Burlington House, Piccadilly, London, W.1, "Hydraulics in Industry," R. H. Bound, 5.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Nov. 6.—Central Electricity Authority Headquarters, Winsley Street, London, W.1, "Meteorological Aspects of the International Geophysical Year," D. W. S. Limbert, 6.45 p.m.

Advanced Engineering Courses

Operational Research. UNIVERSITY OF BIRMINGHAM. Institute for Engineering Production, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course, Monday, November 25 to Friday, December 6. Fee £50.